SESSION 2

NEW COMPOUNDS AND NEW CONCEPTS IN WEED CONTROL

Proceedings 1982 British Crop Protection Conference - Weeds

PP 333 - A NEW BROAD SPECTRUM GROWTH RETARDANT

B.G. Lever
I.C.I Plant Protection Division, Fernhurst, Haslemere, Surrey

S.J. Shearing and J.J. Batch
I.C.I Plant Protection Division, Jealotts Hill Research Station, Bracknell, Berkshire

Summary. PP 333, (2RS 3RS)-1-(-4-Chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4 triazol-1-yl) pentan-3-ol, is a new broad spectrum growth retardant with a wide range of potential uses. These include the control of lodging in graminaceous crops, management of growth of ornamental plants, turf grass and trees and regulation of fruit tree growth.

The compound is of low toxicity to mammals and many other organisms.

Gibberellin biosynthesis, Lodging, rice, grass seed, turf, fruit, trees, ornamentals.

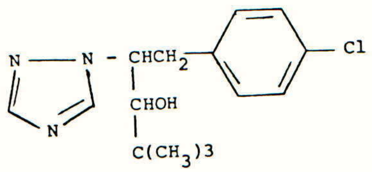
INTRODUCTION

PP333, proposed common name paclobutrazol, is a new plant growth regulator currently being developed by ICI. Extensive field testing in several countries has shown the compound to be a very broad spectrum growth retardant producing dose related reductions in vegetative growth without scorch or phytotoxicity. This paper describes the principal biological properties and demonstrates potential benefits in a range of crops.

CHEMICAL AND PHYSICAL PROPERTIES

Chemical name	:	(2RS, 3RS)-1-(4-chlorophenyl)-4,4-dimethyl -2-(1H-1,2,4-triazol-1-yl)pentan-3-ol
Proposed common name	:	Paclobutrazol
Code number	:	PP 333
Empirical formula	:	$C_{15}H_{20}Cl\ N_3O$

Structural formula :



Molecular weight : 293.5

Appearance : White crystalline solid

Melting point : 165-6°C

Density : 1.22 g/cm^3

Solubility : In water 35 mg /l, methanol 15%, propylene glycol 5%, acetone 11%, cyclohexanone 18%, methylene dichloride 10% hexane 1% and xylene 6%

Vapour pressure : 1 x 10^{-6} Pa at 20°C

Stability : Stable at temperatures up to 50°C for at least six months

Formulation : PP 333 can be formulated as a w.p., suspension concentrate or granule

TOXICOLOGY

Toxicity studies carried out to date indicate that PP 333 is of low mammalian toxicity. The acute and dermal LD50 values to the rat are approximately 1 500 and 1 000 mg /kg respectively. It is classified as slightly irritant to rat and mildly irritant to rabbit skin and is slightly to moderately irritant to rabbit eyes.

PP 333 is also of low toxicity to birds, fish and invertebrates. The acute oral LD50 to mallard ducks is in excess of 8 000 mg /kg. The LC50 (96 hours) for rainbow trout (Salmo gairdneri) is 33.1 mg /l.

No detrimental effects on earthworms or microarthropods were observed following two annual applications to field plots at 10 kg a.i./ha/yr.

MODE OF ACTION

PP 333 appears to inhibit gibberellin biosynthesis and reduces cell division and extension. Effects are dose related and are not accompanied by phytotoxicity or scorch. Retardation can be reversed by application of gibberellic acid.

It is readily taken up through roots, stems and foliage, but is translocated almost exclusively in the xylem. Hence PP 333 sprayed onto the foliage accumulates in leaves and little reaches the meristematic areas of cell division and extension; the sites of action for the compound as a growth regulator. For PP 333 to reach these areas uptake is needed through roots or exposed stems.

While the principal activity is as a growth regulator, PP 333 also has useful fungicidal properties.

RESULTS

Biological Activity

Efficacy and potential applications of PP 333 are exemplified in this paper on a number of diverse crops.

Graminaceous Crops

PP 333 is active on a wide range of graminaceous crops, shortening and strengthening the internodes of flowering stems and, at higher rates of application, reducing foliage growth. There are no adverse effects on reproductive organs.

Major practical applications of the stem shortening properties are to reduce lodging and, in certain crops, increase yield. Results on wheat, barley and rye have previously been reviewed in detail by Froggatt et al, 1982, demonstrating the strong relationships between the effects of PP 333 sprays on stem height, strength, lodging resistance and crop yield. In paddy rice, granular applications have decreased stem height, reduced lodging and increased yields of lodging prone varieties under standard fertilizer regimes. They have also enabled further increases in yield to be obtained by altering the crop's response to nitrogen (Table 1).

Table 1

Effects of PP 333 on rice height, lodging and yield
(data from Wakayamo Prefectural Agricultural Experimental Station, Japan
Hirano, 1982)

Treatment[a]		Nitrogen level kg/ha	Crop height at Maturity cm	Lodging[b]		Yield[c]
Chemical	Rate g a.i./ha			20 Days[c] After Heading	Maturity	
PP 333	240	80	81	0	0-1	112
PP 333	240	100	97	0	0-1	116
IBP[d]	8500	80	92	0-1	1	104
IBP	8500	100	96	0-1	1	107
Untreated		80	100	3	4	100
Untreated		100	105	3	5	88

a. Treatments applied 35 days before heading
b. Lodging assessed on 0 (nil) to 5 (very severe) scale
c. Expressed as a percentage of standard 80 kg/ha fertilizer level control value.
d. IBP is the Japanese common name for S-benzyl 0,0-di-isopropyl-phosphorothioate, a compound which is registered as a fungicide for rice. It has PGR activity and has been used as a reference in the absence of a registered PGR standard.

The use of PP 333 enabled the extra nitrogen to produce increases in grain yield rather than excessive vegetative growth and yield losses due to greater susceptibility to lodging.

Yield increases achieved when lodging is prevented are due to increased 1 000 grain weights, ear number and percentage of ripe grains.

Two other attributes have been observed in rice. PP 333 induces a more erect and exposed flag leaf which may aid efficiency of light interception. The compound is also effective in regulating seedling growth in seed boxes prior to transplanting.

In grass seed crops a number of valuable agronomic benefits have been demonstrated. Grass crops are usually vigorous cultivars, selected for foliage production, and are very prone to lodging, leading to substantial yield losses and harvesting difficulties (Hebblethwaite et al, 1978). Lodging frequently occurs well before maturity, reducing light penetration into the crop, decreasing numbers of fertile tillers and seed set per spikelet. PP 333 applied prior to stem extension markedly reduced lodging and increased yield (Hebblethwaite et al, 1982; Faulkner, 1981). A trial on perennial rye grass in Oregon U.S.A. illustrates these benefits (Table 2).

Germination of seed from treated crops is unaffected.

The fungicidal properties of PP 333 also provide beneficial control of rusts (Puccinia spp) and mildews (Erysiphe graminis).

Table 2

Effect of PP 333 on lodging and yield of Caravelle perennial ryegrass (Chilcote, 1981)

Treatment	Rate g a.i./ha	Lodging index [b]	Yield as % of untreated value
PP 333[a]	250	2.6	150
PP 333	500	1.7	160
Untreated	-	6.9	100

a. Applied at spikelet initiation
b. On a 0 (no lodging) to 10 (complete lodging) scale

The efficacy of PP 333 in reducing total vegetative growth of grasses opens potential opportunities for the compound as a management aid for amenity turf (Shearing and Batch, 1980 and 1981).

Root uptake leads to greatest activity in periods of higher rainfall, when maximum growth control is needed. Risks of overdosing and discolouration under unexpectedly dry conditions are also much reduced. The root uptake properties enable growth control to be maintained through successive mowings. PP 333 does not affect seedheads although flowering stems are reduced in height by over 50%. Where effective suppression of seedheads is also required, mixtures with complementary compounds with seedhead control properties, e.g., mefluidide, can provide excellent results (Table 3).

Table 3

Effects of PP333/Mefluidide mixtures on Festuca arundinacea on an uncut roadside, USA

Treatment[a]	Rate kg a.i./ha	Foliage retardation[b]	% Seedhead suppression
PP 333	2.3	40	0
Mefluidide	0.4	20	85
PP 333 + mefluidide	1.1 + 0.15	70	90
PP 333 + mefluidide	2.3 + 0.3	70	95
Maleic hydrazide	3.4	20	80

a. Chemicals were applied at the end of April

b. Data were recorded 9 weeks after treatment and are expressed as percentages of the untreated values.

Woody and annual broad-leaved crops

PP 333 is active on a number of woody and annual broad leaved crops. Particularly interesting results have been obtained on fruit trees, where potential benefits include:

- control of tree vigour and enhancement of fruit bud development

- reduction in pruning requirements

- better light penetration, resulting in improved fruit quality and colour

- control of powdery mildew (Podospheara leucotricha) and scab (Venturia inaequalis) on apples

- increased frost tolerance

Results on apples have previously been reported by a number of authors including Quinlan, 1980 and Tukey, 1981 and are illustrated in Table 4. Further trials have confirmed activity on pears, peaches, apricots, nectarines, cherries, plums, walnuts and almonds.

Table 4

Effect of PP 333 foliar sprays on shoot growth of red deciduous apples, USA

Treatment	Rate mg /l	No of applications	Mean shoot growth as % of untreated
PP 333	250	3[a]	40
PP 333	750	1[b]	48
Untreated	-	-	100
Mean value on untreated			46 cm

a. 3 applications at 14 day intervals, 1st spray at petal fall.
b. 1 application 14 days after petal fall.

Control of tree growth has been achieved by foliage sprays and by applications to the soil at the base of the trees.

In apples, foliage sprays can arrest new vegetative growth within 4-6 weeks of application leading to the formation of a resting terminal bud. The effect from a single spray at 2 000 mg /l can be transient in vigorous orchards and lead to further growth later in the growing season. Sequential sprays at lower rates overcome this and offer the potential to apply PP 333 when needed in relation to tree growth.

Because of its acropetal mobility, PP 333 does not appear to be transported into the fruit. Studies so far have shown little effect on fruit size.

Injection of chemical directly into the trunk is proving an attractive means of controlling growth of ornamental trees and reducing the need for pruning.

The stem shortening properties and lack of adverse effects on flower development offer considerable scope for retardation of ornamentals. Dwarfing has been achieved on over 30 different species (Shanks, 1981; Wilfret, 1981; Menhennet, 1981; Menhenett and Hanks, 1982). Internode shortening can be achieved by single application foliage sprays (stem uptake) and soil drenches without any delay in time to bloom. A relatively shallow dose response minimises risk of overdosing. Some typical responses to PP 333 on chrystanthemum are illustrated in Table 5.

Table 5

Effect of PP 333 soil drenches and foliar sprays in comparison with standard treatments on chrysanthemum

Treatment				Crop height[a] as % of untreated
Method of application	Chemical	Rate of a.i. application	No of applications	
Foliar spray	PP 333	188 mg /l	1	38
Foliar spray	PP 333	375 mg /l	1	42
Foliar spray	PP 333	750 mg /l	1	42
Foliar spray	ancymidol	188 mg /l	1	44
Foliar spray	daminozide	2 500 mg /l	2	46
Soil drench[b]	PP 333	0.125 mg /pot	1	65
Soil drench[b]	PP 333	0.25 mg /pot	1	48
Soil drench[b]	ancymidol	0.25 mg /pot	1	45
Untreated				100

a. Measured 34 days after treatment
b. Soil drench applied at 150 ml per 6 in pot.

Activity has also been demonstrated on a number of other broad leaved plants including legume cover crops, cotton and aquatic weeds. In most of these the principal effect has been the reduction of internode length. In sugar beet, leaf size and petiole length are reduced leading to a more prostrate habit (Jaggard et al, 1982). While root weights are relatively unaffected, no yield benefits have been demonstrated from population density experiments.

DISCUSSION

PP 333 is a highly active systemic plant growth retardant with potential agronomic value in a very diverse range of uses. It opens the way to totally novel opportunities for plant growth regulation which will be selectively developed.

REFERENCES

Chilcote, D.O. (1981). Personal communication.

England, D.J.F. (1978). PP333 - A new grass retardant. In : Amenity grassland; an ecological perspective, I.H. Rorison and R. Hunt (Eds), Wiley, 234.

Faulkner, J.S. (1981). The effects of PP333 on lodging and yield in seed crops of Lolium perenne. Record of Agricultural Research, Dept.of Agriculture for Northern Ireland, 29, 47-51.

Froggatt, P.J., Thomas, W.D., Batch, J.J. (1982). The value of lodging control in winter wheat as exemplified by the growth regulator PP333. In : Opportunities for manipulating cereal productivity, A.F. Hawkins B. Jeffcoat (Eds). BPGRG Monograph 7, in press.

Hebblethwaite, P.D., Burbidge, A., Wright D. (1978). Lodging studies in Lolium perenne grown for seed. Journal of Agricultural Science, 90, 261-267.

Hebblethwaite, P.D., Hampton J.G., McLaren, J.S. (1982). The chemical control of growth, development and yield of Lolium perenne grown for seed. In : Chemical Manipulation of Crop Growth and Development, J.S. McLaren (Ed) University of Nottingham 33rd Easter School in Agricultural Science, 505-524.

Hirano, R., (1982). Personal communication.

Jaggard, J.W., Lawrence, D.K., Biscoe, P.V., (1982). An understanding of crop physiology in assessing a plant growth regulator on sugar beet. In : Chemical Manipulation of Crop Growth and Development, J.S. McLaren (Ed). University of Nottingham 33rd Easter School in Agricultural Science, 139-150.

Menhenett, R., (1981). Studies with plant growth regulators. Report Glasshouse Crops Research Institute 1980, 76-77.

Menhenett, R., Hanks, G.R., (1982). New retardant shows promise for pot-grown lilies and tulips. The Grower, 97, 17-20.

Shanks, J.B., (1981). Chemical dwarfing of several ornamental greenhouse crops with PP333. In : Proceedings of the Plant Growth Regulator Working Group 1980, 46-51

Shearing, S.J., Batch, J.J. (1980). PP333-field trials to control growth of amenity grasses. In : Recent Developments in the Use of Plant Growth Retardants. D.R. Clifford and J.R. Lenton (Eds). BPGRG Monograph 4, 87-97.

Shearing, S.J., Batch, J.J. (1982). Amenity grass retardation - some concepts challenged. In : Chemical Manipulation of Crop Growth and Development, J.S. McLaren (Ed.), University of Nottingham 33rd Easter School in Agricultural Science, 467-483.

Quinlan, J.D. (1980). Recent developments in the chemical control of tree growth. Acta Horticulturae, 114, 144-151.

Quinlan, J.D. (1981). New Chemical approaches to the control of fruit tree form and size. Acta Horticulturae, 120, 95-106.

Tukey L.D. (1981). The growth regulator PP 333 on apples. Hortscience, 16, 401.

Wilfret, G.J. (1981). Height retardation of poinsettia with ICI - PP333. Hortscience, 16, 443.

Proceedings 1982 British Crop Protection Conference - Weeds

HOE 33171 - A NEW SELECTIVE HERBICIDE FOR THE CONTROL OF ANNUAL AND PERENNIAL WARM CLIMATE GRASS WEEDS IN BROADLEAF CROPS

H. Bieringer, G. Hörlein and P. Langelüddeke
Hoechst Aktiengesellschaft, Frankfurt (M) 80, West-Germany

R. Handte
Hoechst Aktiengesellschaft, Werk Gersthofen, West-Germany

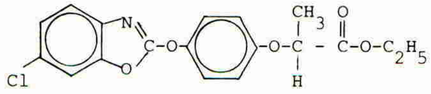
Summary. Hoe 33171, ethyl 2 [4(6-chloro-2-benzoxazolyloxy-)-phenoxy-] -propanoate, is a new post-emergence herbicide for the selective control of annual and perennial grass weeds primarily for use in broadleaf crops. Extensive field trials covering a wide range of agricultural and climatic conditions have demonstrated its consistently excellent activity against warm climate grass weeds. It is very safe to all non-graminaceous crops tested. Annual and seedling perennial grasses are well controlled by rates ranging between 0.10 - 0.20 kg/ha a.i. For the control of the perennial rhizome grass weeds Sorghum halepense and Cynodon dactylon split applications or even higher rates are required, depending upon the agricultural practice used and the cropping situation. Chemical, physical properties, toxicological data, crop tolerance, control / Setaria, Digitaria, Sorghum halepense, Cynodon dactylon.

INTRODUCTION

Hoe 33171, ethyl 2 [4(6-chloro-2-benzoxazolyloxy-)-phenoxy-] -propanoate, proposed common name fenoxaprop-ethyl, is a new post-emergence herbicide for the selective control of annual and perennial grass weeds primarily for the use in broadleaf crops. It was discovered in the laboratories of the Hoechst AG and is currently being developed preferably for the selective use in warm climate countries. Field trials conducted since 1978 in many countries covering a wide range of agricultural and climatic conditions have demonstrated the consistently excellent efficacy against warm climate grass weeds. This paper gives general information on fenoxaprop-ethyl and reports results from 3 years testing between 1979 and 1981 in 5 main climatic regions representative of the global trial programme.

CHEMICAL AND PHYSICAL PROPERTIES

Structure :



Chemical name:	Ethyl 2 [4(6-chloro-2-benzoxazolyloxy-)-phenoxy-] propanoate
Proposed common name:	fenoxaprop-ethyl
Code number:	Hoe 33171
Molecular weight:	361.8
Appearance:	colourless and odourless solid

Melting point:	84°C - 85°C	
Boiling point:	approximately 200°C at 100 Pa	
Solubility at 20°C:	water	0.9 mg/l (at 25°C)
	hexane	> 0.5 %
	cyclohexane	> 1 %
	ethanol	> 1 %
	1-octanol	> 1 %
	acetone	> 50 %
	toluole	> 30 %
	ethylacetate	> 20 %
Vapour pressure:	0.19×10^{-5} Pa at 20°C	
Formulation:	9 e.c. and 12 e.c., containing 90 or 120 g/l a.i.	

TOXICOLOGY

Acute oral LD50 (mg/kg) of technical material

Rat:	male	2357	female	2500
Mouse:	male	4670	female	5490
Dog:	male/female	no reaction at 1000 mg/kg		

Acute dermal LD50 (mg/kg) of technical material

Rat: female > 2000

Acute intraperitoneal LD50 (mg/kg) of technical material

Rat: male 739 female 864

Subchronic toxicity (90-day feeding study)

Dog: male/female 'no effect'-level 16 ppm
Rat: male/female 'no effect'-level 80 ppm

Hoe 33171 is slightly irritant to rabbit skin and slightly irritant to rabbit eye mucosa (EPA Guidelines). It is non-mutagenic in the Ames Test.

MODE OF ACTION

Hoe 33171 is primarily absorbed through the plant leaves and moves in both the xylem and the phloem. The actual site of action is the meristematic tissue of the shoot, where an accumulation of the active ingredient takes place (Köcher et al., 1982).

The first visible symptom appears 2 - 3 days after application when a cessation of growth is to be seen; along with it, new leaves or secondary roots are no longer formed. Chlorosis begins on young leaves then necrosis spreads over leaves and shoot. Slowly the whole plant dies, which may take 2 to 4 weeks depending on climatic conditions.

Good growing conditions generally favour the effectiveness of Hoe 33171 while speed of action is slowed down at low temperature and low humidity or moisture levels.

METHODES AND MATERIALS

The numerous field trials reported in this paper to illustrate the herbicidal activity of Hoe 33171 were carried out in West-Germany, Spain, Italy, USA, South Africa,and Brasil in the years 1978 to 1981.

Formulations of Hoe 33171 used were 9 e.c. and 12 e.c. However, no basic difference in their biological acitivity has been reported. All trials were of randomised block design using 3 replicates except in a very few where 2 or 4 replicates were used. Plot size in all trials was 2 m x 5 m.

All treatments were applied with air pressurized hand carried plot sprayers at volume rates of 300 - 500 l/ha using 'Tee-Jet' nozzles at a pressure of about 200 kPa.

Visual assessments and weed counts were made to determine the herbicidal efficacy. The crops were rated for vigour, stand reduction, and injury.

RESULTS

International field results from different climatic regions are summarized by crop tolerance and weed control of annual and perennial grass weeds.

Crop tolerance

Broadleaf crops have shown principal tolerance to Hoe 33171; rates at least three times those required for effective grass weeds control have been fully tolerated.

Table 1

Crops shown to be tolerant to Hoe 33171 at 1.5 kg/ha a.i. applied post-emergence

Clover	Potatoes
Cotton*	
Field beans (*Vicia faba*)	Soybean
Groundnuts	
Lucerne	Sugar beet
Oilseed rape	Sunflower
Peas (*Pisum sativum*)	Tobacco

* Cotton is tolerant to at least twice the rate required for effective grass weed control. Rates above 0.5 kg/ha a.i. may cause slight but short term phytotoxicity by leaf spots only.

Graminaceaous crops are sensitive to Hoe 33171 with the exeption of wheat and rye. Selective use in cereals is not possible according to our present stage of knowledge.

Annual grass control

Results from greenhouse evaluation and limited field trials comparing pre- and post-emergence activity of Hoe 33171 against annual grass weeds have shown this compound to be much more active when applied post-emergence, although it has also revealed good pre-emergence activity. Under certain conditions this may ensure a useful soil component of activity.

A list of grass weeds susceptible to Hoe 33171 applied post-emergence is given in table 2.

Table 2

List of grass species susceptible to post-emergence application of Hoe 33171. (The rates indicated are required to give 85 % or more weed control)

Very sensitive species (0.05 - 0.25 kg/ha a.i.)	
Alopecurus myosuroides	*Avena sativa* (volunteer oats)
Avena fatua	*Avena sterilis*
Avena ludoviciana	*Brachiaria* spp.

Digitaria sanguinalis
Echinochloa colonum
Echinochloa crus-galli
Eleusine africana
Eleusine indica
Eragrostis virescens
Eriochloa contracta
Leersia oryzoides
Leptochloa spp.
Panicum capillare
Panicum maximum
Panicum dichotomiflorum
Phalaris spp.
Rotboellia exaltata
Setaria faberi
Setaria glauca
Setaria viridis
Sorghum bicolor
Sorghum halepense
Sorghum sudanense
Sorghum verticilliflorum
Zea mays (volunteer maize)

Sensitive species (0.5 - 1.0 kg/ha a.i.)
Bromus spp.
Cynodon dactylon
Hordeum vulgare (volunteer barley)
Secale cereale (volunteer rye)
Triticum aestivum (volunteer wheat)

Moderately resistant species (greater than 1 kg/ha a.i.)
Agropyron repens
Lolium multiflorum
Lolium perenne
Festuca ovina
Festuca pratensis
Festuca rubra
Poa annua
Poa pratensis

Typical field results of annual grass weed control as collected from three years field trial work (1978 - 1981) with Hoe 33171 is reported from West Germany (Table 3), USA (Table 4), Spain and Italy (Table 5) and South Africa (Table 6).

All these weed control assessments demonstrate the excellent activity of Hoe 33171 against grass weeds under a wide range of agricultural and climatic contions.

Table 3

Annual grass weed control by Hoe 33171 in Germany (Trial summary 1978 - 1981*)

Grass weed	Percent control at the rate of 0.18 - 0.25	0.30 - 0.40 kg/ha a.i.
Alopecurus myosuroides	86 (29)	96 (15)
Avena fatua	97 (15)	99 (8)
Digitaria sangninalis	87 (9)	92 (9)
Echinochloa crus-galli	94 (13)	98 (5)
Setaria viridis	92 (12)	99 (9)

Assessments made 22 - 78 days after application
( ) = number of trials
Weed stage: 4 leaves - end of tilling
*Summary from 65 trials, carried out at Hattersheim/Frankfurt and 22 trials spread over Germany;
Weeds not controlled: L. perenne, P. annua, A. repens,

The results even show that relatively low rates of 0.10 - 0.20 kg/ha a.i. of Hoe 33171 are needed to give good control of advanced growth stages of grass weeds, because many ratings have been taken from treatments applied at the late tillering stage of weeds.

Table 4

Control of annual grass weeds by Hoe 33171 in the USA (1978 - 1981)

Grass species	Percent control at the rate of 0.10		0.18 - 0.20		0.36 - 0.40 kg/ha a.i.	
Brachiaria platyphylla	-		92	(1)	88	(3)
Digitaria sanguinalis	97	(4)	93	(7)	96	(7)
Echinochloa crus-galli	95	(6)	91	(11)	94	(10)
Eleusine indica	96	(2)	96	(13)	97	(15)
Eriochloa contracta	92	(2)	97	(12)	99	(13)
Setaria viridis/glauca	99	(4)	99	(8)	100	(7)
S. halepense (seedling)	95	(5)	94	(20)	97	(14)
Zea mays (volunteer maize)	95	(3)	98	(8)	100	(9)

Weed stage: 3 - 4 leaves to late tillering
Assessments: 14 - 52 days after application
Trial summary from different sites near Greenville/Miss.
Weeds not controlled: Cyperus spp.

Table 5

Control of grass weeds by Hoe 33171 in Spain and Italy (Summary from field trials 1978 - 1981)

Country	Grass weed	Percent control at the rate of 0.10		0.18 - 0.20		0.24 - 0.27 kg/ha a.i.	
Spain	Avena sterilis	-		94	(8)	99	(6)
	D. sanguinalis	98	(1)	98	(1)		
	E. colonum	96	(2)	100	(2)		
	P. paradoxa	-		82	(5)	92	(4)
Italy	Avena sterilis	-		94	(4)	92	(4)
	E. crus-galli	-		94	(5)	96	(10)
	P. brachystachis	-		92	(5)	93	(5)
	Phalaris spp.	-		81	(2)	86	(2)

Assessments: 26 - 50 days after application
Weed stage: 3 - 4 leaves to midtillering
Weeds not controlled: Paspalum distichum, Cyperus rotundus

Table 6

Control of grass weeds by Hoe 33171 in South Africa (Trial summary 1978 - 1981)

Grass species	Percent control at the rate of 0.10		0.18 - 0.20		0.30 - 0.40 kg/ha a.i.	
Digitaria sanguinalis	88	(2)	98	(6)	100	(9)
Echinochloa colonum	-		100	(3)	100	(3)
Eleusine africana	-		97	(8)	99	(8)
Eragrostis virescens	-		90	(2)	98	(1)
Panicum maximum	-		93	(8)	100	(7)
Setaria verticillata	-		96	(3)	100	(4)
Sorghum halepense	98	(2)	99	(1)	100	(2)
S. sudanense	-		98	(3)	-	
S. verticilliflorum	-		100	(1)	100	(1)

Evaluations: 13 - 42 days after application
Weed stage: 3 - 4 leaves to end of tillering

Perennial grass control

Hoe 33171 has given excellent control of S. halepense in soybeans with single applications of 0.15 - 0.20 kg/ha a.i. If regrowth occurs a second application of 0.10 - 0.15 kg/ha a.i. is required (Table 7).

Table 7

Control of Sorghum halepense by Hoe 33171 applied by single and sequential treatments (Summary of 2 trials, USA)

Rate kg/ha a.i.	Percent control of S. halepense (weeks after application)			
	2	4	6	Harvest
0.15	94	79	65	61
0.20	95	81	70	70
0.25	95	82	70	70
0.15 + 0.15	94	80	90	87

Growth stage of S. halepense: 20 - 40 cm tall
Sequential treatments were made 5 weeks from initial treatment

Preliminary trial results from the USA indicate that perennial C. dactylon can be well controlled in crops on arable land by rates as low as 0.2 kg/ha a.i. However in case of regrowth a second application at a similar rate may be required.

Good control of an established stand of C. dactylon was obtained in plantations under different climatic regimes and results are presented in Table 8.

Table 8

Control of Cynodon dactylon (established stand) by Hoe 33171 in plantations

Country/site	Rate kg/ha a.i.	Assessment time days after application	Percent control
Italy/vineyard	1.44	28	83 (2)
	2.40	28	90 (2)
	1.44	84	75 (2)
	2.40	84	80 (2)
South Africa/ mango	1.0	28/38	81 (2)
	2.0	28/38	89 (2)
Brasil/citrus	2.0	42	90 (1)

( ) number of trials

DISCUSSION

Hoe 33171 is a highly effective, systemic herbicide which has demonstrated its great potential for the selective post-emergence control of numerous annual and perennial weeds of the subtropical and tropical climate. The compound is primarily safe to non-graminaceous crops.

Effective post-emergence control of annual grass weeds by Hoe 33171 is achieved even at advanced growth stages of weeds; therefore, along with a certain soil residual activity against germinating grass weeds a marketed flexibility of application as well as a long term effectiveness is offered by this product.

Problem perennial grass weeds like S. halepense and C. dactylon are effectively and selectively controlled in agricultural broadleaf crops and in plantations.

ACKNOWLEDGEMENTS

The assistance of other members of Hoechst AG in the execution of the trials, and for supplying materials and technical data, respectively, is acknowledged. The authors wouls like to thank those co-operators, who supplied the land and crops used in the trials.

REFERENCES

Köcher, H., Kellner, H.M., Lötzsch, K. and Wink, O. (1982). Mode of action and metabolic fate of the herbicide Hoe 33171. Proceedings 1982 British Crop Protection Conference - Weeds.

Schumacher, H. Röttele M. and Marrese R. J. (1982). Grass weed control in soybeans by Hoe 33171. Proceedings 1982 British Crop Protection Conference - Weeds.

Proceedings 1982 British Crop Protection Conference - Weeds

HOE 35609, A NEW SELECTIVE HERBICIDE FOR THE CONTROL OF ANNUAL AND PERENNIAL TEMPERATE CLIMATE GRASS WEEDS IN BROADLEAF CROPS

R. Handte
Hoechst Aktiengesellschaft, Werk Gersthofen,
8906 Gersthofen, West Germany

H. Bieringer, G. Hörlein and F. Schwerdtle
Hoechst Aktiengesellschaft, 6230 Frankfurt (M) 80, West Germany

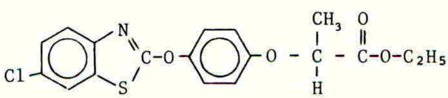
Summary. Hoe 35609, ethyl 2 [4 (6-chloro-2-benzothiazolyloxy)-phenoxy]-propanoate, is a new very effective post-emergence herbicide for the selective control of annual and perennial grass weeds primarily for use in broadleaf crops of the temperate climate zone. Extensive field trials over the last four years have shown it can be safely used (up to doses of 1.5 kg a.i./ha) in a lot of different crops tested to control major grass weeds. The rate required for the control of established Agropyron repens ranges between 0.24 - 0.6 kg a.i./ha, while annual grass weeds are well and consistently controlled by rates ranging between 0.06 - 0.24 kg a.i./ha. Hoe 35609 has a low order of mammalian toxicity. Chemical and physical properties, toxicological data, crop tolerance, control of Agropyron repens, Alopecurus, Avena, Volunteer cereals.

INTRODUCTION

Hoe 35609, proposed common name fenthiaprop-ethyl, is a new herbicide being first synthesized in 1976 and currently developed by Hoechst AG. Field tests in several countries of the temperate climate zone have shown that fenthiaprop-ethyl is highly active against annual and perennial grass weeds without any activity against broadleaf crops. Preferentially the product is used post-emergence, though it possesses a certain pre-emergence activity as indicated by a small number of trials. The residual pre-emergence activity is only of short persistance. The paper gives general information on Hoe 35609 and reports results from some field trials representative of the extensive programme during recent years.

CHEMICAL AND PHYSICAL PROPERTIES

Structure:



Chemical name: Ethyl 2 [4 (6-chloro-2-benzothiazolyloxy)-phenoxy]-propanoate

Proposed common name: fenthiaprop-ethyl

Code number: Hoe 35609

Molecular weight: 377.8

Melting point:	56 - 57.5 °C	
Boiling point:	approximately 220 °C at 100 Pa	
Solubility at 20 °C:	water	0.8 mg/l (at 25 °C)
	hexane	> 1 %
	ethanol	> 5 %
	cyclohexane	> 4 %
	1-octanol	> 5 %
	toluole	> 50 %
	ethylacetate	> 50 %
	acetone	> 50 %
Vapour pressure:	0.51×10^{-6} Pa at 20 °C	
Formulation:	24 e. c., containing 240 g/l a. i.	

TOXICOLOGY

Hoe 35609 is of low order of toxicity as it has been shown by the results from the acute and sub-acute toxicological studies.

Acute oral:	mouse:	male	LD50	1030 mg/kg
		female	LD50	1170 mg/kg
	rat:	male	LD50	977 mg/kg
		female	LD50	919 mg/kg
	dog:	female and male		125 mg/kg without any reaction
		female and male		250 mg/kg and 500 mg/kg vomiting
Acute dermal:	rat:	female	LD50	2000 mg/kg
Acute intraperitoneal:	rat:	male	LD50	690 mg/kg
		female	LD50	589 mg/kg
Subchronic toxicity:	(90 day feeding study)			
	rat:	no effect level 50 mg/kg		

Hoe 35609 is slightly irritant to rabbit skin and eye mucosa (EPA Guidelines).

Hoe 35609 is non-mutagenic in the Ames Test.

MODE OF ACTION

Hoe 35609 is mainly taken up by the leaves and moves in both the phloem and xylem.

Within 2 - 3 days after application the growth of the plants is stopped. The actual site of action is the meristematic tissue of the shoot, where an accumulation of the active ingredient takes place. Chlorosis begins on young leaves then necrosis spreads over leaves and shoot. The speed of action depends on the atmospheric conditions. Normally the plants are completely killed within 2 - 4 weeks.

Under favourable growth conditions they die even quicker; whilst contrary conditions delay the action.

METHODS AND MATERIALS

The field trials reported in this paper to illustrate the herbicidal activity of Hoe 35609 were carried out in West Germany and France in the years 1978 to 1981.

Formulation of Hoe 35609 used was 24 e. c. All trials were of randomised block design using 3 - 4 replicates. Plot size in all trials was 2 m x 5 m.

All treatments were applied with air pressurized hand carried plot sprayers at volume rates of 300 - 500 l/ha using "Tee-Jet" nozzles at a pressure of about 200 kPa.

Visual assessments and weed counts were made to determine the herbicidal efficacy. The crops were rated for vigor, stand reduction and injury.

RESULTS

Field trials are summarized by crop tolerance and weed control of annual and perennial grass weeds.

Crop tolerance

At this time all non-graminaceous crops that have been tested showed tolerance to Hoe 35609. No influence of the growth-stage could be detected.

Table 1

Crops shown to be tolerant to Hoe 35609 by post-emergence sprays (dosage 1.5 kg a.i./ha)

Carrot	Peas
Clover	Potatoes*
Cotton	Soybean
Field beans	Strawberries
Flax	Sugar beet
Linseed	Sunflower
Lucerne	Tobacco
Oilseed rape*	Vines

* occasionally at this extremely high dosage very slight symptoms of phytotoxicity (leaf spots) have been noticed in oilseed rape and potatoes 8 - 15 days after spraying, however in no case were long term effects visible.

Graminaceous crops like wheat, barley, maize, sorghum, oats and rye are all very sensitive to Hoe 35609. Therefore no selective use of Hoe 35609 seems to be possible. However, due to the high sensitivity of wheat, barley and oats toward Hoe 35609, the product will be usefull in controlling volunteer cereals in broadleaf crops (see Tables 3 and 4).

Tolerance of grasses

Table 2

Tolerance of grass species to Hoe 35609

Very sensitive species (0.05 - 0.24 kg/ha a.i.)	
Agropyron repens	*Avena sativa* (volunteer oat)
Alopecurus myosuroides	*Avena sterilis*
Apera spica-venti	*Echinochloa crus-galli*
Avena fatua	*Eleusine indica*
Avena ludoviciana	*Hordeum* spp. (volunteer barley)

Table 2
(continuation)

Ischaemum rugosum	Phalaris spp.
Leptochloa spp.	Triticum spp. (volunteer wheat)
Lolium spp.	Zea mays (volunteer maize)
Susceptible species (0.24 - 1.0 kg/ha a.i.)	
Brachiaria spp.	Panicum maximum
Bromus rigidus	Setaria faberi
Cynodon dactylon	Setaria viridis
Digitaria sanguinalis	Sorghum halepense
Eriochloa contracta	
Resistant species (>1 kg/ha a.i.)	
Cyperus spp.	Poa spp.
Festuca spp.	

Annual grass control

Results from different trials in West Germany and France are given in Tables 3 and 4.

Table 3

Control of annual grass species by Hoe 35609
(West Germany 1978 - 1981)

Grass weed	Percent control at rates of 0.09 - 0.1	0.18 - 0.24 kg/ha a.i.
Alopecurus myosuroides	92 (5)	99 (8)
Apera spica-venti	-	91 (3)
Avena fatua	84 (7)	94 (11)
Echinochloa crus-galli	90 (3)	97 (8)
Lolium perenne	-	99 (5)
Volunteer barley	92 (2)	99 (5)
Volunteer wheat	90 (2)	94 (5)

Stage: 3 - 4 leaves - end of tillering
( ) : indicates number of trials
Assessments: 22 - 78 days after application

Table 4

Control of annual grass species by Hoe 35609
(France 1980/1981)

Grass weed	Percent control at rates of 0.12	0.18	0.24 kg/ha a.i.
Alopecurus myosuroides	100 (4)	99 (8)	100 (8)
Avena fatua	99 (3)	100 (3)	100 (3)
Avena ludoviciana	-	99 (8)	99 (8)
Lolium multiflorum	-	87 (3)	93 (3)
Volunteer wheat	100 (1)	100 (2)	100 (2)
Volunteer barley	100 (1)	100 (5)	100 (5)

Stage: 3 - 4 leaves to early tillering
( ) : indicates number of trials

Assessments: 28 - 126 days after application

The results from Tables 3 and 4 show that Hoe 35609 is highly active against the temperate annual grass species. Post-emergence grass weed control was excellent at 0.09 - 0.24 kg/ha a.i. and the rate required was independent of the growth stage.

Control of Agropyron repens

Results from different trials in Germany are given in Table 5. Trials have been carried out in sugar beet, potatoes and oilseed rape.

Table 5

Control of perennial Agropyron repens by Hoe 35609 at different rates (Germany 1979 - 1981)

Rate kg/ha a.i.	0.18	0.24	0.36	0.54
% control 35 - 57 days after application	60 (6)	82 (10)	87 (10)	93 (11)

( ) : indicates number of trials
Stage of A. repens at the application time was mid-tillering to shooting, the level of infestation 10 - 40 % soil cover.

As the results show, Hoe 35609 is very active against A. repens even at low rates. In further trials it could be demonstrated, that at such high rates of infestation split application is favourable (Schumacher et al., 1982).

DISCUSSION

Hoe 35609 is a highly effective, systemic herbicide. It has shown high activity against numerous annual and perennial weeds of the temperate climate zone, especially from post-emergence application.

Hoe 35609 is selective to broadleaved crops.

Due to its very good activity against cereals, Hoe 35609 will be used to control volunteer weeds in broadleaf crops.

The control of annual grass weeds with post-emergence applications of Hoe 35609 is achieved independently from the growth stages of the weeds, even advanced plants are very well controlled.

Together with a certain soil residual activity, Hoe 35609 therefore offers a marked flexibility of application as well as long term effectiveness.

A.repens is effectively and selectively controlled by Hoe 35609.

ACKNOWLEDGEMENTS

The assistance of other members of Hoechst AG and of members of RU-Procida/ France in the execution of the trials, and for supplying materials and technical data, respectively, is acknowledged.

REFERENCES

Schumacher, H.; Hess, M.; Schwerdtle, F.; Manning, T. H.: Grass weed control in oilseed rape, sugarbeet and potatoes with Hoe 35609. Proceedings 1982 British Crop Protection Conference - Weeds.

Proceedings 1982 British Crop Protection Conference - Weeds

AC 222,293 A NEW POSTEMERGENT HERBICIDE FOR CEREALS: GREENHOUSE STUDIES

D. L. Shaner, K. Umeda, D. R. Ciarlante and M. Los
American Cyanamid Company, Agricultural Research Division,
P. O. Box 400, Princeton, NJ 08540 U.S.A.

Summary. AC 222,293 is a new postemergence herbicide with excellent selectivity in wheat and barley. The compound has low mammalian toxicity with good activity on Avena fatua, Alopecurus myosuroides, and Brassicaceae species, while giving suppression of other troublesome weeds. AC 222,293 is active due to uptake through both foliage and root system of emerged plants. A non-ionic surfactant is necessary for maximal herbicidal activity.

Cereal herbicide, novel chemistry, post-emergence, Avena, Alopecurus, Sinapsis.

INTRODUCTION

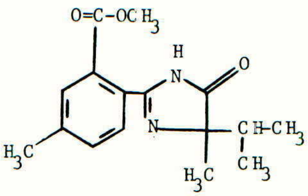
AC 222,293, a mixture of methyl 6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-m-toluate and methyl 2-(4 isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-p-toluate, is a new foliarly-applied herbicide being developed by American Cyanamid for control of Avena spp., Alopecurus myosuroides, and certain broadleaved weeds in wheat and barley. This herbicide has been field tested in the U.S.A., Canada, and Europe since 1979. Field results are described by Kirkland and Shafer (1982). A weed and crop spectrum for AC 222,293 has been reported by Richardson et al. (1981). The purpose of this paper is to describe some of the biological properties of AC 222,293 based on greenhouse studies.

Chemical and Physical Properties: Chemical names (IUPAC):
(a) methyl 6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-m-toluate, and,
(b) methyl 2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-p-toluate.

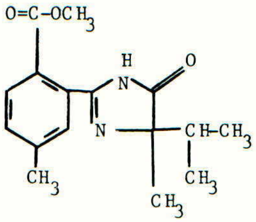
Other Designations: AC 222,293

Molecular Formula: $C_{16}H_{20}N_2O_3$

Structural Formulae:



a.



b.

Molecular Weight: 288.35

Color and Physical State: White to off white crystalline solid.

Odor: Odorless.

Melting Point: 120–145 °C.

Solubility: Soluble in some common organic solvents. Water solubility (at pH 5.95 and 25 °C) is 1360 ppm for the m-isomer and 850 ppm for the p-isomer (Mangels, 1982).

Partition Coefficient (n-octanol/water): m-isomer, 60; p isomer, 35 (Mangels, 1982).

Mammalian Toxicity: The technical product is of very low toxicity by single oral dosage and single dermal application (Table 1) and is a non-irritant to the rabbit eye.

Table 1

Acute mammalian toxicity of AC 222,293 technical

Test	Result
Acute oral LD_{50} (mg/kg body wt) Male rat	> 5000
Acute dermal LD_{50} (mg/kg body wt) Male rabbit	> 2000

(Fischer, 1982)

Mutagenicity: AC 222,293 is non-mutagenic as determined by the Ames test (Ames et al., 1975) (Allen, 1982).

Metabolic Studies: Radiobalance studies in the rat showed that ^{14}C-derived residues of both m and p isomers of AC 222,293 were excreted rapidly and completely following administration of a single oral dose, there being no accumulation in tissues or blood (Chiu, 1982).

In studies with excised leaf tissue (Shaner et al., 1982) the levels of the free carboxylic acids of AC 222,293 were elevated in *Avena fatua* and *A. myosuroides* as compared with wheat. The free acids are believed to be the phytotoxic principle.

Residues: Residues of parent compound in grain and straw of wheat and barley following postemergence applications of AC 222,293 at exaggerated dosages were very low, i.e. 0.05 and 0.09 to 0.10 ppm respectively (Devine, 1982).

METHODS AND MATERIALS

Seeds of the test species were planted in pots filled with a loamy sand soil (o.m. 5%) and grown for two weeks in the greenhouse. Most treatments were applied with a moving-belt sprayer in a spray volume of 374 l/ha unless otherwise indicated. For the weed and crop spectrum studies, analytical-grade herbicide was dissolved in 80:20 acetone:H_2O (V/V) with 0.25% (V/V) of 'Igepal DM710' surfactant. In other studies formulated 50% w.p. AC 222,293 was suspended in water. In the adjuvant study, the surfactants were all applied on a volume:volume basis.

The site of application studies were done by applying AC 222,293 50% w.p. either directly to the soil as a drench or to the foliage with the soil protected by a layer of vermiculite. After the foliage had dried the vermiculite was removed.

Herbicidal activity was visually assessed 5 weeks after application using a 0 to 9 scale (0 = no effect, 9 = complete kill).

RESULTS

Weed and crop spectrum: AC 222,293 has excellent postemergent selectivity on both wheat and barley under greenhouse conditions (Table 2). It did not show any selectivity on other crops such as oilseed rape, flax, sugarbeets, or legumes (Table 2). The weed spectrum of AC 222,293 at rates which are safe on the cereals included *A. fatua*, *A. myosuroides*, *Solanum nigrum*, *Sinapis arvensis*, and *Polygonum pensylvanicum* (Table 3). AC 222,293 has also shown activity on *Convolvulus arvensis* (Table 3).

Table 2

Crop selectivity of post-em. applications of AC 222,293 in greenhouse

Crop	Safe rate (kg/ha)
Soybean (Glycine max)	> 0.063
Sunflower (Helianthus annuus)	0.125
French bean (Phaseolus vulgaris)	> 0.063
Lima bean (Phaseolus lunatus)	> 0.063
Lucerne, alfalfa (Medicago sativa)	0.500
Tomato (Lycopersicum esculentum)	> 0.063
Sugarbeet (Beta vulgaris)	> 0.063
Flax, linseed (Linum usitatissimum)	0.125
Rape (Brassica napus)	> 0.063
Maize (Zea mays)	2.000
Sorghum (Sorghum bicolor)	0.500
Rice (Oryza sativa)	0.500
Spring wheat (Triticum aestivum)	3.000
Winter wheat (Triticum aestivum)	3.000
Winter barley (Hordeum vulgare)	3.000

Table 3

Weed spectrum from post-em. applications of AC 222,293 in greenhouse

Species	Control rate (kg/ha)
Perennials	
Agropyron repens	> 4.000
Sorghum halepense	> 4.000
Convolvulus arvensis	0.063
Broadleaves	
Solanum nigrum	0.125
Bidens pilosa	0.500
Matricaria spp.	2.000
Chenopodium album	0.250
Xanthium pensylvanicum	1.000
Ipomoea spp.	> 4.000
Sida spinosa	1.000
Abutilon theophrasti	0.250
Sinapis arvensis	0.125
Ambrosia artemisiifolia	2.000
Amaranthus retroflexus	> 4.000
Polygonum pensylvanicum	0.250

Table 3 (continued)

Species	Control rate (kg/ha)
Grasses	
Setaria viridis	> 4.000
Setaria faberi	> 4.000
Sorghum bicolor	> 4.000
Lolium perenne	> 4.000
Phalaris spp.	> 4.000
Brachiaria spp.	> 4.000
Alopecurus myosuroides	0.250
Eleusine indica	> 4.000
Panicum dichotomiflorum	> 4.000
Rottboellia exaltata	> 4.000
Avena fatua	0.250
Echinochloa crus-galli	2.000
Digitaria spp.	> 4.000

Adjuvants: For optimal activity a nonionic surfactant is necessary (Table 4). The optimal surfactant concentration, depending on spray volume, lies between 0.1 and 0.25% (V/V).

Table 4

Effect of surfactant on postemergent activity of AC 222,293

Surfactant	Control rate (kg/ha) A. myosuroides	A. fatua	S. arvensis	Safe rate (kg/ha) Wheat (cv. Anza)	Barley (cv. Larker)
-	1.0	0.5	0.5	2.0	2.0
+	0.5	0.25	0.25	2.0	2.0

Site of Uptake: The site of uptake of AC 222,293 appears to be both through the foliage and root system of the plant. A. fatua can be effectively controlled when the herbicide is applied either as a soil drench or directly to the foliage while the soil is protected (Table 5). This dependence on the soil route can also be shown when the effect of different soil types on the herbicidal activity of AC 222,293 are compared. On heavier soils, more AC 222,293 was required to control A. fatua (Table 6) although the herbicide was applied postemergent to the weed.

Table 5

Effect of growth stage and site of application on the post-em. activity of AC 222,293

Rate (kg/ha)	Application site	Growth stage (Zadocks)	Herbicidal activity: A. fatua Fresh wt (% of control)	Herbicidal activity: Wheat Fresh wt (% of control)
0.5	Soil	11	11.7	96.4
0.5	Soil	12	16.7	100.0
0.5	Soil	13	10.4	100.0
0.5	Soil	15	6.9	100.0
1.0	Soil	11	0.0	100.0
1.0	Soil	12	9.2	100.0
1.0	Soil	13	3.9	100.0
1.0	Soil	15	3.4	100.0
0.5	Foliar	11	55.0	100.0
0.5	Foliar	12	0.0	100.0
0.5	Foliar	13	0.0	100.0
0.5	Foliar	15	5.6	100.0
1.0	Foliar	11	33.9	94.6
1.0	Foliar	12	2.4	100.0
1.0	Foliar	13	0.0	100.0
1.0	Foliar	15	3.2	100.0

Table 6

Effect of soil texture on post-em. activity of AC 222,293 50% w.p.

Location	Soil type	o.m. (%)	A. fatua Control rate (kg/ha)	Wheat Safe rate (kg/ha)
California	Sandy loam	0.3	0.5	1
Princeton	Sandy loam	1.5	0.5	2
Mississippi	Silt loam	1.8	0.5	1
Wisconsin	Clay loam	4.9	1.0	2
Greenhouse	Loamy sand	5.0	1.0	2
Indiana	Loam	8.3	2.0	2
New York	Peat	58.2	2.0	2

DISCUSSION

Greenhouse tests have shown that AC 222,293 is highly active when applied foliarly to A. fatua, A. myosuroides and certain dicotyledonous weeds primarily in the Brassicaceae and Polygonaceae families. Richardson et al. (1981) found a similar weed spectrum. AC 222,293 has excellent selectivity on both wheat and barley in the greenhouse. Field results reported by Kirkland and Shafer (1982) fully support these greenhouse results. A nonionic surfactant is necessary for maximal activity. However, AC 222,293 can enter through both the roots and the foliage of emerged plants. Studies on the translocation of the herbicide have shown that it is both xylem and phloem mobile (Shaner et al. 1982). The importance of the soil route is further illustrated by the effect of soil type on the activity of AC 222,293. Furthermore, rain fastness studies in the greenhouse showed that simulated rainfall immediately after application of AC 222,293 did not decrease its efficacy on A. fatua.

AC 222,293 does demonstrate preemergence activity, but field results have shown that control of susceptible weeds is much more erratic when the herbicide is applied preemergence. Selectivity on the cereals is also reduced from preemergence application of AC 222,293.

Based on greenhouse and field evaluations to date, AC 222,293 offers the promise of becoming an effective postemergent herbicide for control of A. fatua, A. myosuroides and certain dicotyledonous weeds in wheat and barley.

ACKNOWLEDGEMENT

I would like to acknowledge Dr. J. Allen and the Toxicology Group for providing data on the toxicology and mutagenicity aspects of AC 222,293 and Dr. P. Miller and the Metabolism group for data on the solubility, partition coefficients data, and animal metabolism data on AC 222,293. I would also like to acknowledge Dr. J. Devine and the Residue Chemistry group for residue data.

REFERENCES

Allen, J. (1982). Personal communication.

Ames, B. N.; McCann, J.; Yamasaki, E. (1975). Methods for detecting carcinogens and mutagens with Salmonella/mammalian microsomes mutagenicity test. Mutation Research, 31, pp. 347-364.

Chiu, T. (1982). Personal communication.

Devine, J. (1982). Personal communication.

Fischer, J. (1982). Personal communication.

Kirkland, K.; Shafer, N. E. (1982). AC 222,293: a new postemergent herbicide for cereals: field results. Proceeedings 1982 British Crop Protection Conference - Weeds.

Mangels, G. (1982). Personal communication.

Richardson, W. G.; West, T. M.; Parker, C. (1981). The activity and postemergence selectivity of some recently developed herbicides: SSH-41, MB 30755, AC 213,087, AC 222,293, and Dowco 455. Technical Report Agricultural Research Council Weed Research Organization, 63, pp. 60.

Shaner, D. L.; Simcox, P. D.; Robson P.; Mangels, G; Reichert, B; Ciarlante, D. R., Los, M. (1982). AC 222,293 - absorption, translocation, and metabolic selectivity. Proceedings 1982 Bristish Crop Protection Conference -Weeds.

AC 222,293 A NEW POST-EMERGENCE HERBICIDE FOR CEREALS: FIELD STUDIES

K. Kirkland and N. E. Shafer
American Cyanamid Company, Agricultural Research Division,
P. O. Box 400, Princeton, N. J. 08540

Summary. AC 222,293, a mixture of methyl 6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-m-toluate and methyl 2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)-p-toluate is a new post-emergence herbicide for cereals which is highly active on *Avena* spp., *Alopecurus myosuroides*, *Apera spica-venti*, and some broadleaved weeds such as *Sinapis arvensis*, *Raphanus raphanistrum* and *Polygonum convolvulus*. AC 222,293 is selective in virtually all varieties of wheat and barley so far tested. Cereal herbicide, novel chemistry, post-emergence, *Avena*, *Alopecurus*, *Apera*.

INTRODUCTION

AC 222,293 is a post-emergence herbicide for cereals discovered at American Cyanamid Company's Agricultural Research Center in Princeton, New Jersey, U.S.A. The compound represents novel chemistry in the pesticide field (Los *et al.*, 1982). Performance, toxicologic, metabolic and residue studies are under way to support registration and commercial development. The purpose of this paper is to introduce AC 222,293 and to present some representative data from field trials carried out in Europe and the U.S.A. in 1981 and 1982. Results from greenhouse studies were reported by Shaner *et al.* (1982). Their paper also outlines toxicology, metabolism and residue studies completed to date on AC 222,293.

METHODS AND MATERIALS

Unless otherwise stated, results reviewed and presented are from replicated small-plot trials laid out on farmers' fields. Herbicide applications were made with various types of plot sprayers delivering from 200 to 500 ℓ/ha at pressures ranging from 1500 to 2250 mmHg. AC 222,293 treatments were applied post-emergence to both crop and weeds, the growth stages of which were recorded. Unless otherwise stated, all AC 222,293 treatments were as the 50% w.p. and included 0.25% V/V a.i. of a non-ionic surfactant. Randomized block designs with 3 or 4 replications were used.

Various methods were used to assess weed control. These are indicated in the relevant tables.

RESULTS

United Kingdom

Results from the 1981 season are summarized in Table 1. Addition of a non-ionic surfactant improved the control of *Avena fatua* by AC 222,293 but *Alopecurus myosuroides* control was not improved. At 0.4 kg a.i./ha, control of *A. fatua* by AC 222,293 was equivalent to that obtained by difenzoquat at 1.0 kg a.i./ha. Good control of *A. myosuroides* required 0.8 kg a.i./ha AC 222,293.

No significant phytotoxicity to any of the wheat or barley varieties in these trials was recorded.

Table 1

Efficacy of AC 222,293 in winter cereals in the U.K. in 1981

Treatment	Dosage (kg a.i./ha)	% control of indicated weed species* *Avena fatua*	*Alopecurus myosuroides*
AC 222,293	0.2	79(4)**	57(2)
+ non-ionic surfactant	0.4	90(4)	72(2)
	0.8	94(4)	89(2)
AC 222,293 without surfactant	0.4	80(5)	69(5)
difenzoquat	1.0	88(5)	-

*Assessments by spikelet counts on *Avena* and by panicle counts on *Alopecurus*.
**Figures in brackets denote numbers of trials from which means derived.
Growth stages at application - *A. fatua* Zadoks 11-30 (Zadoks *et al.*, 1971)
A. myosuroides Zadoks 12-26
Crops Zadoks 21-31

France

Results from the 1981 season are summarized in Table 2. A dosage of 0.8 kg a.i./ha AC 222,293 gave good control of *A. fatua*, *Avena ludoviciana* and *A. myosuroides*.

Some phytotoxicity to winter wheat var. Ducat was recorded at 1.6 kg a.i./ha but no significant injury was seen at 0.8 kg a.i./ha. Addition of surfactant did not have a noticeable effect on selectivity but did improve control of *A. ludoviciana*.

Table 2

Efficacy of AC 222,293 in winter cereals in France in 1981

Treatment	Dosage (kg a.i./ha)	% control of indicated weed species* *Avena fatua*	*Avena ludoviciana*	*Alopecurus myosuroides*
AC 222,293	0.2	74(3)**	61(5)	-
+ non-ionic surfactant	0.4	85(3)	76(5)	-
	0.8	93(3)	94(5)	-
	1.6	95(3)	99(2)	-
AC 222,293	0.2	-	40(6)	50(4)
without surfactant	0.4	-	66(6)	71(4)
	0.8	-	88(6)	91(4)
	1.6	-	97(6)	99(4)
difenzoquat	1.0	85(3)	94(7)	-
chlortoluron	2.5	35(3)	54(8)	98(4)

*Assessments made by spikelet and panicle counts.
**Figures in brackets denote numbers of trials from which means derived.
Growth stages at application - *Avena* spp. Zadoks 10-23
A. myosuroides Zadoks 12-22
Crops Zadoks 13-30

West Germany

Results from the 1981 season are summarized in Table 3. Excellent control of *A. fatua*, *Apera spica-venti* and *Raphanus raphanistrum* was obtained with 0.4 kg a.i./ha AC 222,293 plus non-ionic surfactant. At this dosage, with surfactant, control of *A. myosuroides* was equivalent to isoproturon at 1.5 kg a.i./ha and chlortoluron at 2.5 kg a.i./ha. Addition of surfactant enhanced the activity of AC 222,293 on *A. myosuroides* in these trials in contrast to the U.K. results.

Early applications (Zadoks 13) to winter wheat var. Diplomat at 0.8 and 1.6 kg a.i./ha AC 222,293 caused slight and moderate thinning respectively but other varieties were unaffected.

Table 3

Efficacy of AC 222,293 in winter cereals in West Germany 1981

Treatment	Dosage (kg a.i./ha)	% control of indicated weed species* *Avena fatua*	*Alopecurus myosuroides*	*Apera spica-venti*	*Raphanus raphanistrum*
AC 222,293	0.2	93(2)**	76(3)	-	-
+ non-ionic surfactant	0.4	98(2)	94(3)	96(3)	100(1)
	0.8	100(2)	98(3)	98(3)	100(1)
AC 222,293	0.2	82(2)	41(5)	-	-
without surfactant	0.4	96(4)	77(7)	-	-
	0.8	100(2)	87(5)	-	-
	1.6	100(2)	93(5)	-	-
chlortoluron	2.5	82(3)	96(8)	100(3)	-
isoproturon	1.5	87(2)	95(6)	96(3)	-

*Visual assessments and counts of panicles and spikelets.
**Figures in brackets denote numbers of trials from which means derived.
Growth stages at application - *A. fatua* Zadoks 21-30
A. myosuroides Zadoks 13-30
A. spica-venti Zadoks 21-25
R. raphanistrum 1-2 leaves
Crops Zadoks 13-20

Italy

Results from the 1981 and 1982 season are summarized in Table 4.

(a) 1981 season.
At a dosage of 0.4 kg a.i./ha, AC 222,293 gave excellent control of *A. ludoviciana* and *A. myosuroides*. *Polygonum convolvulus* was completely controlled with a dosage of 0.2 kg a.i./ha. At 0.4 kg a.i./ha, control of *A. ludoviciana* was equivalent to that obtained with diclofop-methyl and difenzoquat and control of *A. myosuroides* was superior to chlortoluron. No phytotoxicity was observed on any wheat cultivar in these trials which included the most important durum wheat varieties in Italy.

(b) 1982 season.
The excellent performance observed in 1981 with AC 222,293 against both *A. ludoviciana* and *A. myosuroides* was again obtained in 1982. Dosages of 0.25 and 0.3 kg a.i./ha respectively, gave excellent results on these species. Again, no phytotoxicity was recorded.

Table 4

Efficacy of AC 222,293 in winter wheat in Italy

% control of indicated weed species*

1981

Treatment	Dosage (kg a.i./ha)	*Avena ludoviciana*	*Alopecurus myosuroides*	*Polygonum convolvulus*
AC 222,293	0.2	94 (4)**	82(4)	100(3)
	0.4	99 (4)	94(4)	100(3)
	0.8	99.5(4)	97(4)	100(3)
	1.6	100 (3)	100(4)	100(3)
diclofop-methyl	0.7	97 (3)	92(2)	15(2)
difenzoquat	1.35	98 (1)	-	-
chlortoluron	2.0	-	84(2)	-

1982

Treatment	Dosage (kg a.i./ha)	*Avena ludoviciana*	*Alopecurus myosuroides*
AC 222,293	0.25	95 (10)	-
	0.3	-	98(1)
	0.5	98 (10)	99(1)
	1.0	99.5(10)	100(1)
diclofop-methyl	0.7	95 (10)	74(1)
difenzoquat	1.0	89 (3)	-
benzoylprop-ethyl	0.8	93 (3)	-

*Visual assessments in 1981, spikelet counts in 1982.
**Figures in brackets denote numbers of trials from which means derived.
Growth stages at application:

<u>1981</u>

A. ludoviciana - Zadoks 12-26

A. myosuroides - Zadoks 10-20

P. convolvulus - 1 to 2 leaves

Crops - Zadoks 13-26

<u>1982</u>

A. ludoviciana - Zadoks 13-31

(Zadoks 29 for benzoylprop-ethyl)

A. myosuroides - Zadoks 25-29

Crops - Zadoks 21-31

(Zadoks 31-32 for benzoylprop-ethyl)

Timing Trials - Europe

In the 1982 season trials were carried out designed to determine timing/dosage relationships for maximum effectiveness against *Avena* spp., *A. myosuroides* and *A. spica-venti*. Results from U.K., France and Germany were similar and are summarized in Table 5. *Avena* spp. showed maximum susceptibility to AC 222,293 from applications between Zadoks 10 and 21 and *A. myosuroides* between Zadoks 24 and 32. The control of *A. spica-venti* appears to be less dependent on growth stage at application but more data are needed on this species.

The very dry weather this season before and following application of AC 222,293 reduced the control of *A. myosuroides* compared with 1981. However, results were still superior to those obtained with isoproturon, which was also affected by the dry conditions.

The selectivity of AC 222,293 was not affected.

Table 5

Efficacy of AC 222,293 in winter cereals when applied at different timings
Data from U.K., France and Germany - 1982

Treatment	Dosage (kg a.i./ha)	Timing	% control of indicated weed species* *Avena* spp. (6 trials)	*Alopecurus myosuroides* (8 trials)	*Apera spica-venti* (1 trial)
AC 222,293	0.5	1	90	63	98
		2	68	66	89
		3	64	71	91
	0.625	1	95	66	98
		2	87	66	94
		3	82	82	99
	0.75	1	88	82	100
		2	82	76	99
		3	86	82	92
difenzoquat	1.0	3	76(3 trials)	-	-
isoproturon	2.0	2	-	68(5 trials)	-

*Visual assessments and counts.
Timing (Zadoks):

1	*Avena* spp.	10-21	*A. myosuroides*	10-21	*A. spica-venti*	11-13
2	" "	21-24	" "	21-24	" " "	13-22
3	" "	24-30	" "	24-32	" " "	22-26

U.S.A. - 1982

Data from trials in spring wheat are summarized in Table 6. Outstanding control of *A. fatua* was obtained with AC 222,293 at treatment rates of 0.42 to 0.84 kg a.i./ha, with the 0.42 kg a.i./ha rate providing equivalent control to difenzoquat at 1.12 kg a.i./ha. In a limited comparison, AC 222,293 at 0.70 kg a.i./ha was equivalent to diclofop-methyl at 1.12 kg a.i./ha. Selectivity of all treatments was excellent.

Table 6

Efficacy of AC 222,293 in spring wheat in U.S.A. - 1982

Treatment	Dosage (kg a.i./ha)	% control of *Avena fatua**
AC 222,293	0.42	90(6)**
(240 g/ℓ e.c.)	0.56	91(6)
	0.70	96(3)
	0.84	94(5)
difenzoquat	0.84	81(5)
	1.12	90(2)
diclofop-methyl	0.84	68(1)
	1.12	95(1)

*Visual assessments.
**Figures in brackets denote numbers of trials from which means derived.
Growth stages at application - *A. fatua* AC 222,293 Zadoks 12-13
difenzoquat Zadoks 13-14
diclofop-methyl Zadoks 12

DISCUSSION

AC 222,293 is a promising new post-emergence herbicide for the control of *Avena* spp., *A. myosuroides*, *A. spica-venti* and some broadleaved weeds in winter and spring cereals. It possesses excellent selectivity in virtually all varieties of wheat and barley so far tested.

Addition of a non-ionic surfactant is required for optimal activity of AC 222,293. Prolonged dry conditions following applications may reduce activity, particularly against *A. myosuroides* since the product is active through both the foliage and the soil (Shaner *et al.*, 1982).

Results in Southern Europe (Italy) have shown that lower dosages than those required in Northern Europe are effective against *A. ludoviciana* and *A. myosuroides*. The reasons for this are not known.

ACKNOWLEDGEMENTS

Grateful acknowledgement is given to Cyanamid field teams in Europe and the U.S.A. who carried out the trial work reported in this paper.

REFERENCES

Los, M., Ciarlante, D. R., Ettinghouse, E. M., Wepplo, P. J. (1982). o-(4-oxo-2-imidazolin-2-yl) arylcarboxylates: A New Class of Herbicides. Proc. American Chemical Society (In Press).

Shaner, D. L., Umeda, K., Ciarlante, D. R. (1982). AC 222,293 a new post-emergent herbicide for cereals: greenhouse studies. Proceedings 1982 British Crop Protection Conference - Weeds.

Zadoks, J. C., Chang, T. T., Konzak, C. F. (1974). A decimal code for the growth stages of cereals. Weed Research, 14, 415-421.

CGA 84446 : A NEW HERBICIDE FOR THE CONTROL OF BROAD-LEAVED WEEDS IN CEREALS, PRE- AND POST-EMERGENCE

H.R. Gerber and W. Maurer
Ciba-Geigy Ltd., Basle, Switzerland

Summary. 2'-methoxyethyl 2-/5-(2-chloro-4-trifluoromethylphenoxy)-2-nitrophenoxy/-propionate is a new selective herbicide active against a wide range of broadleaved weeds, including hard-to-kill species, in wheat and barley. Laboratory and greenhouse tests have demonstrated its low soil mobility and adequate duration of activity; foliar activity is very high. At 0.25-0.5 kg a.i./ha, CGA 84446 is a particularly suitable partner for chlortoluron in pre-emergence applications. Post-emergence at rates of 0.125-0.25 kg a.i./ha it can be mixed with isoproturon and/or chlortoluron. In both applications, these mixtures control both grasses and problem broadleaved species such as Galium aparine, Viola spp. and Veronica spp. At very low rates, 50-150 g a.i./ha, it can be used to increase the effect of many other commercial herbicide mixtures on these same broadleaved weeds. Results against atrazine resistant broadleaved weeds in maize, orchards and vineyards are also promising. Viola, Veronica, Galium, triazine resistant weeds.

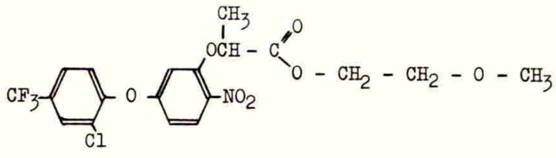
INTRODUCTION

Galium aparine, Viola spp. and Veronica spp. have become a problem in many cereal growing regions of Europe because the herbicides which have been used until now have had only a limited activity against these weeds.

CGA 84446 is a new compound from the chemical group of the diphenylethers. After three years of intensive field testing it will be developed in order to improve the control of those difficult broadleaved weeds in cereals.

Chemical and physical properties

Structural formula:



Molecular formula:	$CH_{19} H_{17} Cl F_3 NO_7$
Chemical name:	2'-methoxyethyl 2-/5-(2-chloro-4-trifluoromethylphenoxy)-2-nitrophenoxy/-propionate
Code number:	CGA 84446
Melting point:	62.9°C
Vapour pressure at 20°C:	7.8×10^{-8} Pa
Water solubility at 20°C:	0.5 mg/l
Solubility in organic solvents at 20°C:	soluble in most organic solvents
Formulation:	25% e.c.

Toxicity of technical material

Acute oral (rat) LD50:	5 000 mg/kg
Acute dermal (rat) LD50:	2 000 mg/kg
Irritation skin (rabbit):	minimal
Irritation eye (rabbit):	minimal

Mode of action

So far the mode of action of nitro-diphenylethers has only partly been elucidated. It is known that they do not act as photosystem II-inhibitors. Their herbicidal activity is attributed to the loss of plant membrane integrity (Ashton and Crafts, 1982).

This is manifested, in the case of CGA 84446, as necrosis of shoot and root meristems caused by pre-emergence applications, and as rapid necrosis and desiccation of the stems and leaves following post-emergence treatments on sensitive weeds.

METHODS AND MATERIALS

Experiments in laboratory and growth chambers

All the experiments of which the results are reported below have been carried out by means of bioassays as described by Gerber (1975). Soil from Stein, Switzerland, with the following properties has been used: 2.2% organic carbon, 38% clay, 17% silt, 45% sand. All experiments have been conducted under controlled-environment conditions in growth chambers. The experiments for the determination of the spectrum of activity have been carried out in the greenhouse with a temperature of 18°C during the day and 10°C during the night.

Field experiments

All trials have been conducted in naturally-infested fields. The plot size varied from 10-20 m^2. All experiments had 3 replications. About 150 trials have been laid down, in Switzerland, United Kingdom, France, Germany and Austria.

RESULTS

Experiments in laboratory and growth chamber

Soil behaviour

Table 1

Leaching and degradation in days under standardized laboratory conditions

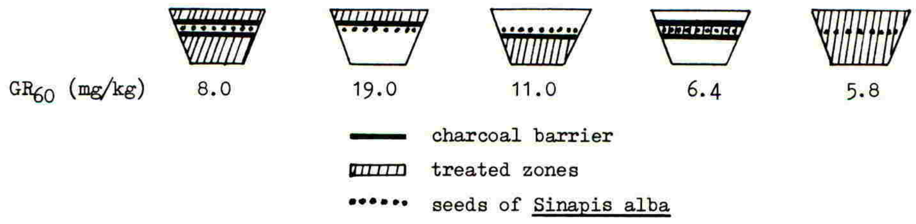
Compound	Leaching index cm on thick layer soil chromatography	Days for 50% degradation
CGA 84446	4	42
Chlortoluron	6	46
Atrazine (standard)	10	55

The results of the leaching behaviour study reported in Table 1 have been obtained using thick-layer soil chromatography, and include comparison with chlortoluron and the standard for these tests, atrazine. Higher values mean greater mobility. The degradation behaviour, in comparison with the same standards, is also shown in Table 1. The degradation of CGA 84446 is similar to that of chlortoluron. Therefore one can expect a similar, adequate duration of activity with both under field conditions.

The site of uptake has been studied. Fig. 1 shows the results of a placement study with Sinapis alba as the test plant. The lowest value of GR_{60} (the rate needed to inhibit growth by 60% on a fresh weight basis) is 5.8 mg/kg, recorded when all the soil in the pot was treated. Placement only in the zone where the seeds were sown gave nearly the same values, 6.4 mg/kg. Other placements gave higher values, so that CGA 84446 is most toxic when the compound is placed as closely as possible to the germinating seeds. This fact is especially important if we consider that Viola spp. and Veronica spp. are shallow-germinating weeds.

Fig. 1

CGA 84446 placement study
(pre-emergence application, Sinapis alba)



Foliar activity

In comparison with older standard compounds used to control broadleaved weeds in cereals, CGA 84446 shows a very high foliar activity, requiring rates which are about 10% of those of standards under greenhouse conditions. Its speed of action is high, comparable with that of paraquat; treated broadleaved plants lose their turgor and begin to wilt within 24 hours. After 2 days, necrosis occurs, which rapidly destroys the whole plant. The activity on younger leaves is more pronounced than that on leaves which are fully developed. Special tests have shown that translocation of CGA 8446 in the phloem is negligible.

Spectrum and level of activity under greenhouse conditions

Under greenhouse conditions CGA 84446 is selective in cereals and has a spectrum of activity (Table 2) which makes it particularly suitable for enlarging those of chlortoluron and isoproturon to include difficult weeds like Veronica, Viola and Galium.

Table 2

Dosage rate of CGA 84446 required under greenhouse conditions for <20% damage and >80% activity

	Plant	Pre-emergence kg a.i./ha	Post-emergence kg a.i./ha
Tolerance (<20% damage)	Wheat	2.0	0.25 - 0.5
	Barley	2.0	0.25 - 0.5
Activity (>80% against weeds)	*Sinapis alba*	0.5	0.02
	Stellaria media	0.5	0.04
	Galium aparine	0.5 - 1.0	0.03
	Veronica persica	<0.125	0.02
	Viola tricolor	<0.125	0.02
	Avena fatua	>4.0	0.5
	Alopercurus myosuroides	2.0	0.5

Field experiments

CGA 84446 pre-emergence in cereals

Under normal practical conditions, mixtures of chlortoluron with CGA 84446 at up to 0.75-1 kg a.i./ha are well tolerated by winter barley and winter wheat.

The tolerance of cereals to CGA 84446 is little affected by soil texture or organic matter content, with the exception of sandy soils (>70% sand). However, if sowing is unusually shallow, or if application is delayed after sowing until Zadok's Stages 05-09, or if conditions are extremely wet, tolerance may be reduced, and initial phytotoxicity may occur. Further investigations of the importance and influence on yield of this temporary initial phytotoxicity are under way.

The activity spectrum of the mixture chlortoluron + CGA 84446 is shown in Table 3. It covers all the major grasses and broadleaved weeds occuring in cereals. The strong activity of CGA 84446 against hard-to-kill ones like *Viola* spp. and *Veronica* spp. allows it to be used at low rates (≃0.375 kg a.i./ha) in combination with chlortoluron, and a performance comparable or superior to that of the present standard compounds to be obtained. For season-long control of *Galium aparine*, or in cases where late emergence of broadleaved weeds occurs in the spring, the low rates may have too short an activity and a post-emergence application of CGA 84446 in the spring is necessary.

Table 3

Activity spectrum of chlortoluron + CGA 84446 pre-emergence in winter cereals (rate required to obtain >90% control - not tested)

Chlortoluron (kg a.i./ha)	1.5 - 2.0				2.0 - 2.5				2.5 - 3.0			
CGA 84446 (kg a.i./ha)	0.25	0.375	0.5	0.75	0.25	0.375	0.5	0.75	0.25	0.375	0.5	0.75
Apera spica-venti	X				-	-	-	-	-	-	-	-
Lolium spp.	X				-	-	-	-	-	-	-	-
Poa annua	X				X				-	-	-	-
Alopercurus myosuroides	-	-	-	-	X				X			
Avena fatua	-	-	-	-	-	-	-	-	X	X		
Viola tricolor	X	X			X				X			
Veronica persica	X	X			X	X			X	X		
Veronica hederifolia		X	X			X	X			X	X	
Veronica arvensis		X				X				X		
Galium aparine			X	X			X	X			X	
Stellaria media		X	X		X	X			X	X		
Lamium purpureum	X	X			X				X			
Matricaria chamomilla	X	X			X				X			
Myosotis arvensis	X	X			X				-	-	-	-
Papaver rhoeas	X				X				-	-	-	-
Alchemilla arvensis	X	X			X				-	-	-	-
Capsella bursa-pastoris		X			X				-	-	-	-

CGA 84446 post-emergence in cereals

The mixture chlortoluron + CGA 84446 can also be used post-emergence in winter cereals (Table 4) and performs at least as well as the present standards. It is well tolerated in winter cereals up to a rate of 0.25 kg a.i./ha of CGA 84446. Temporary initial phytotoxicity in form of leaf burning may appear on the cereal shortly after application, but, due to the low rate necessary, the recovery is complete only 2 weeks after application.

In addition, CGA 84446 is suitable for mixing with isoproturon to obtain a selective control of the same large spectrum of weeds in winter and in spring cereals. Excellent results have been observed with 0.125 kg a.i./ha CGA 84446 + 1.5 kg a.i./ha of isoproturon.

CGA is still very active against broadleaved weeds at rates of 0.05-0.1 kg a.i./ha and can therefore become a partner at these rates for other broadleaved weed killers in order to reinforce their activity.

Table 4

Performance of chlortoluron + CGA 84446 post-emergence in winter cereals in France, Switzerland and Austria (average of season 1982, 30-60 days after application)

(number of results in brackets)		chlortoluron 2.0 kg a.i./ha + CGA 84446 0.125 kg a.i./ha	isoproturon 1.32 kg a.i./ha + dinoterb 1.17 kg a.i./ha
Tolerance in % thinning			
Winter wheat	(6)	1%	0%
Winter barley	(9)	6%	2%
Activity in % control			
Alopercurus myosuroides	(3)	97%	97%
Viola tricolor	(4)	99%	50%
Veronica persica	(6)	97%	83%
Veronica hederifolia	(8)	99%	77%
Galium aparine	(7)	100%	51%
Stellaria media	(4)	95%	80%
Lamium purpureum	(4)	100%	80%
Matricaria chamomilla	(3)	93%	100%
Myosotis arvensis	(4)	97%	91%
Papaver rhoeas	(5)	96%	93%

CGA 84446 in crops other than cereals

The strong post-emergence activity of CGA 84446 has also been demonstrated against *Convolvolus arvensis* in vineyards where a good knockdown effect has been obtained. In these trials 0.5 kg a.i./ha of CGA 84446 has equalled 1 kg a.i. paraquat/ha. Further tests are necessary to study the duration of activity in relation to the timing of application.

CGA 84446 has also given promising results pre-emergence in maize as a partner for atrazine to control atrazine resistant weeds like *Amaranthus*, *Chenopodium* and *Solanum*.

DISCUSSION

Data from trials with CGA 84446 from the cereal growing areas of western and northern Europe have been described Outside these regions, it offers also distinct possibilities, especially because of its high post-emergence activity. They are under current investigation.

In conclusion CGA 84446 is a very flexible herbicide, both in terms of its timing of application, and its possibilities for combination with existing herbicides Its unusual spectrum of activity makes it an attractive candidate with which to tackle hitherto unsolved broadleaved weed problems in wheat and barley.

REFERENCES

Ashton, F.M., Crafts, A.S. (1982). Mode of action of herbicides. New York: John Wiley & Sons, pp. 224-235.

Gerber, H.R. (1975). Biotests for herbicide development. In: Crop protection agents, N.R. McFarlane (Ed), London: Academic Press, pp. 307-321.

Proceedings 1982 British Crop Protection Conference - Weeds

EL-107 A NEW SELECTIVE HERBICIDE FOR USE IN CEREALS

F. Huggenberger, E.A. Jennings and P.J. Ryan
Lilly Research Centre Ltd., Erl Wood Manor, Windlesham, Surrey, GU20 6PH

K. W. Burow
Lilly Research Laboratories, a Division of Eli Lilly and Company,
P.O. Box 708, Greenfield, Indiana 46140, U.S.A.

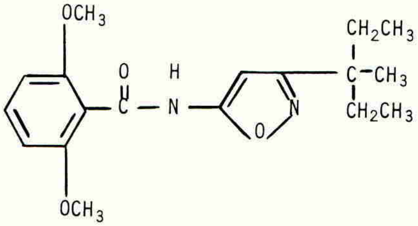
Summary. EL-107 is a new herbicide being developed for the control of broadleaved weeds in cereals. It has been tested in an extensive trial programme in winter cereals in Northern Europe in 1979/80, 80/81 and 81/82. Applied pre-emergence at rates of 100-200 g a.i./ha EL-107 provided consistent, season long control of *Matricaria* spp., *Stellaria media*, *Viola* spp., *Polygonum* spp., *Veronica* spp. and a wide spectrum of other broadleaved weeds. EL-107 is selective up to at least 300 g a.i./ha on wheat and 400 g a.i./ha on barley, thus providing a wide margin of crop safety. Pre-emergence, broadleaved, Matricaria, Veronica, Stellaria, Viola, Polygonum, barley, wheat.

INTRODUCTION

EL-107 is a new herbicide being developed by Eli Lilly & Co., for the pre-emergence control of broadleaved weeds in winter cereals by preventing germination or inhibiting root development of many species. Preliminary testing was carried out in 1979/80 to define the range of useful application rates. This paper provides general information on EL-107 and reports a summary of results from 102 field trials conducted in France, Germany and the UK in 1980/81 and 1981/82 with application rates between 50-200 g a.i./ha and 100-400 g a.i./ha for the evaluation of efficacy and selectivity, respectively.

CHEMICAL AND PHYSICAL PROPERTIES

Structure:



$C_{18}H_{24}O_4N_2$ M.W. = 332.4

Chemical Name: N-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl] -2,6-dimethoxybenzamide

Proposed Common Name: Benzamizole

Appearance:	White crystalline solid	
Melting Point:	170-171 °C	
Stability:	Does not hydrolyze in water at pH 5, 7 and 9. Susceptible to photodegradation in aqueous solution.	
Solubility: (25 °C)	Solvent	Solubility (mg/ml)
	methanol	50-100
	ethyl acetate	50-100
	acetonitrile	30-50
	toluene	4-5
	hexane	0.07-0.08
	water	0.001-0.002
Formulation:	A 50% (wt/V) suspension concentrate is under development.	

ACUTE TOXICITY OF TECHNICAL EL-107

Species	Route	Toxicity
Rat	Oral	LD_{50} > 10 000 mg/kg
	Inhalation	LC_{50} > 1.99 mg/l
Mouse	Oral	LD_{50} > 10 000 mg/kg
Dog	Oral	LD_{50} > 5 000 mg/kg
Rabbit	Dermal	LD_{50} > 200 mg/kg non-irritating
	Ocular	Slight conjunctivitis

Additional toxicology studies are in progress.

CROP RESIDUES

Wheat and barley grain harvested from small field plots treated with 250 g/ha of ^{14}C EL-107 contained radioactive residues equivalent to 0.01 and 0.025 mg/kg EL-107 respectively. Studies are currently in progress to characterize and identify these residues.

METHODS AND MATERIALS

EL-107 was evaluated at 50-200 g a.i./ha for efficacy against broadleaved weeds and at 100-400 g a.i./ha for selectivity in winter wheat and winter barley.

All applications were made using propane or CO_2 pressurised hand held small plot sprayers with flat fan 'tee jet' nozzles, at a pressure of 300 kPa in a spray volume of 200-400 l/ha. Field testing was carried out using an experimental 50% (wt/wt) wettable powder formulation of EL-107. Trials were of randomised block design with four replicates and plots of 25 m^2. Appropriate commercially available products were used as reference treatments in all trials at rates recommended for each country.

Trifluralin + linuron (24 + 12 e.c.) applied at 960 + 480 g a.i./ha was the only product and rate used consistently throughout Germany, France and the UK and was therefore used for comparison with EL-107 in the efficacy and selectivity data presented in this paper. Field trials were visually assessed utilising the Barratt and Horsfall (1945) rating system in France and the UK, or the BBA (Anon. 1966) rating system in Germany, and the values converted to percentages. Assessments of crop selectivity (emergence, population, stand and vigour) and weed control were made both in the autumn and spring, 30 to 110 days and 140 to 180 days after application, respectively.

RESULTS

Efficacy

The mean values from both autumn and spring evaluations for the number of trials indicated, and the range of percent control for the six most commonly occurring broadleaved weeds are presented in Table 1.

Table 1

EL-107 pre-emergence efficacy in winter cereals - % control

Treatment	g a.i./ha		Mean	Min.-Max.		Mean	Min.-Max.
			Matricaria spp.			*Stellaria media*	
EL-107	50	(18)	88	49-100	(10)	88	26-99
	100	(25)	96	70-100	(13)	97	90-100
	150	(21)	99	96-100	(11)	98	89-100
	200	(19)	99	95-100	(10)	99	97-100
trifluralin + linuron	960+ 480	(21)	91	44-100	(14)	97	81-100
			Veronica spp.			*Viola* spp.	
EL-107	50	(32)	78	9-100	(6)	88	49-100
	100	(36)	90	37-100	(9)	93	73-100
	150	(23)	92	37-100	(6)	97	92-100
	200	(23)	95	67-100	(6)	98	93-100
trifluralin + linuron	960+ 480	(34)	87	4-100	(10)	84	27-97
			Polygonum spp.			*Galium aparine*	
EL-107	50	(10)	79	4-100	(11)	41	2-86
	100	(13)	95	84-100	(19)	48	4-100
	150	(11)	98	93-100	(14)	74	29-100
	200	(9)	99	96-100	(16)	70	19-100
trifluralin + linuron	960+ 480	(6)	90	76-97	(21)	52	0-100

Figures in parentheses are the number of trials at that dosage rate.

Results comparable with the reference product against *Matricaria* spp., *Stellaria media*, *Veronica* spp., *Viola* spp., and *Polygonum* spp. were obtained with EL-107 at rates of 50-100 g a.i./ha.

A mean control of 95% or more of *Matricaria* spp., *S. media* and *Polygonum* spp., was obtained with 100 g a.i./ha; of *Viola* spp. with 150 g a.i./ha; and of *Veronica* spp. with 200 g a.i./ha. At these rates there was also a high degree of consistency of control, as indicated by the min.-max. range. Results at the lower end of the range were usually obtained where less than adequate soil moisture was available to fully activate the herbicide.

EL-107 is most active against weeds germinating near the soil surface, hence control of *Galium aparine*, which germinates from differing depths in the soil, was highly variable at any of the rates tested.

Less commonly occurring but locally important weed species, which were controlled to a level of > 90% are listed in Table 2.

Table 2

EL-107 pre-emergence efficacy in winter cereals — other species controlled > 90% at 100-150 g a.i./ha

Aphanes arvensis	(4)	*Juncus bufonius*	(3)
Arabidopsis thaliana	(4)	*Lamium purpureum*	(7)
Atriplex patula	(1)	*Myosotis arvensis*	(3)
Capsella bursa-pastoris	(5)	*Papaver rhoeas*	(4)
Cardamine hirsuta	(1)	*Ranunculus sardous*	(6)
Centaurea cyanus	(4)	*Raphanus raphanistrum*	(3)
Cerastium glomeratum	(1)	*Sinapis arvensis*	(2)
Chenopodium album	(1)	*Spergula arvensis*	(1)
Chrysanthemum spp.	(3)	*Spergularia rubra*	(1)
*Convolvulus arvensis**	(1)	*Thlaspi arvense*	(1)
Fumaria officinalis	(2)	*Urtica urens*	(1)
Galeopsis tetrahit	(1)	*Valerianella locusta*	(2)

Figures in parentheses are the number of trials for that species
* from seed only

Overall it is apparent that EL-107 at rates of 100-200 g a.i./ha is highly effective against a wide range of broadleaved weeds in winter cereals. The results also suggest that where both broadleaved and grass weed control is required, EL-107 at rates of 50-100 g a.i./ha offers good potential for combination with herbicides having predominantly grass weed activity.

Selectivity

The mean values from both autumn and spring evaluations for the number of trials indicated and the range for the selectivity of EL-107 in eleven winter barley and nineteen winter wheat cultivars are presented in Table 3.

Table 3

EL-107 pre-emergence selectivity (crop emergence, population, stand and vigour) in winter cereals - % of control

Treatment	g a.i./ha		Barley Mean	Barley Min.-Max.		Wheat Mean	Wheat Min.-Max.
EL-107	100	(55)	99	86-103	(41)	99	85-103
	200	(33)	99	90-108	(29)	99	89-102
	300	(25)	98	84-109	(21)	98	81-100
	400	(24)	98	85-105	(24)	97	68-101
trifluralin + linuron	960+ 480	(49)	98	78-100	(31)	96	44-103

Figures in parentheses are the number of trials at that dosage rate.

Cultivars: Barley: Alpha, Anthares, Barberousse, Ceres, Gerbel, Igri, Maris Otter, Robur, Sonja, Thibaut, Vogelsanger.

Wheat: Avalon, Bounty, Brigand, Capitole, Castan, Caton, Cocagne, Darius, Disponent, Favori, Fidel, Flanders, Hardi, Lutin, Mardler, Norman, Radja, Talent, Top.

These data demonstrate the excellent selectivity of EL-107 in winter cereals. At all the application rates tested, the mean and minimum selectivity were equivalent or superior to those of the reference product. The only effect on crop development noted has been some reduction in lateral root production after applications in excess of 300 g a.i./ha for wheat and 400 g a.i./ha for barley. This effect was most often associated with poor soil structure where the cereals were shallow rooted. In most cases subsequent crop vigour was unaffected. A number of field trials were carried out where EL-107 was applied post-emergence to winter wheat and winter barley up to growth stage 13 (Tottman and Makepeace, 1979) at application rates of 50-300 g a.i./ha. At all rates tested crop vigour was excellent and no foliar phytotoxicity occurred.

Following Crops

Field trials have demonstrated that the Cruciferae are particularly sensitive to EL-107. Usually therefore, ploughing will be required prior to the seeding of oilseed rape when this crop follows treated cereals in the rotation. Under normal cultivation practices, other major crops following cereals in the rotation such as sugar beet, potato, cereals and maize are not affected by possible soil residues of EL-107. Studies on additional crops which could follow cereals in a rotation are currently in progress.

DISCUSSION

EL-107 provides season long control of annual broadleaved weeds in winter cereals when applied pre-emergence to the crop at rates of 100-200 g a.i./ha. Studies on the behaviour of EL-107 in the soil have demonstrated little mobility in the soil profile under field conditions and indicated a half-life of 5-6 months. This residual activity ensures control of a broad spectrum of both autumn and spring germinating weed species. Under most conditions it will be possible for an autumn pre-emergence treatment of EL-107 to provide weed control throughout the growing season, thus eliminating the possibility of crop yield loss that may occur where weed competition begins before the application of herbicides in the spring.

Its selectivity when applied post-emergence to the crop and pre-emergence to weeds gives some flexibility in timing of application. Additionally EL-107 is being evaluated in combinations at rates of 50-100 g a.i./ha with grass controlling herbicides for situations requiring both broadleaved and grass weed control.

Extensive field trials over three growing seasons have shown that EL-107 at low application rates provides consistent control of a wide spectrum of broadleaved weeds with excellent crop tolerance in the major cereal growing areas in Europe.

ACKNOWLEDGEMENTS

The Authors wish to thank members of the Plant Science Research Teams in Europe and Colleagues at the Lilly Research Centre, Windlesham, U.K., and Lilly Research Laboratories, Greenfield, U.S.A., who have contributed information contained in this paper.

REFERENCES

Anon. (1966). Richtlinien für die Amtliche Prüfung von Pflanzenschutzmitteln der Biologischen Bundesanstalt, Berlin.

Barratt, R.W; Horsfall, T.G. (1945). An improved grading system for measuring plant disease. Phytopathology, 35, 655.

Tottman, D.R; Makepeace, R.J. (1979). An explanation of the decimal code for growth stages of cereals with illustrations. Annals of Applied Biology, 93, 221-234.