'FUSILADE' - A NEW POST-EMERGENCE HERBICIDE FOR THE CONTROL OF GRASS WEEDS IN AUSTRALIA

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Summary. 'Fusilade' (formerly PP009) which contains the selective herbicide fluazifop-butyl, butyl 2-(4-(5-trifluoromethyl-2-pyridyloxy) phenoxy) propionate, has been extensively evaluated in Australia and overseas since 1978. It is highly active on both annual and perennial grass weeds. Excellent and consistent post-emergence control of annual grasses was achieved at rates of 0.125 to 0.5 kg ha^{-1} and of perennial grasses at 1.0 to 2.0 kg ha^{-1} in Australia. Fluazifop-butyl showed excellent crop safety on a wide range of annual broadleaf and tree crops when applied as post-emergence 'over-the-top' sprays at rates as high as 4.0 kg ha^{-1}.

INTRODUCTION

'Fusilade', formerly coded PP009 and containing the active constituent fluazifop-butyl, was invented in mid-1977. It has been developed and registered by ICI in over 25 countries including Australia. Field tests with fluazifop-butyl in Australia, and these countries have confirmed that it is a highly active and systemic herbicide, which is effective against annual and perennial grass weeds, but safe to broadleaf crops. This paper describes the general properties of fluazifop-butyl and presents the results of the field trials and experiences with particular reference to the Australian programme. It also discusses the various factors which influence the biological efficacy of fluazifop-butyl.

MODE OF ACTION

It is known that fluazifop-butyl is quickly absorbed through leaf surfaces. It is then rapidly hydrolysed to the acid, fluazifop, which rapidly translocates both in xylem and phloem, accumulating at growing points and affecting the meristematic tissue of nodes and buds. The mode of action is not yet fully understood. Early results suggest that fluazifop interferes with ATP production and lipid membrane synthesis, leading to the loss of cell walls.

First symptoms are often not evident until a week after application, although growth ceases within 48 hours (Fig. 1). After 7 days nodes and growing points become necrotic with general loss of vigour, and often pigment changes associated with senescence. Death is usually complete within 3-5 weeks.

MATERIALS AND METHODS

The initial screens consisted of both pre-emergent and post-emergent applications of fluazifop-butyl to a range of dicotyledonous and monocotyledonous crops and weeds. Subsequent field trials consisted mainly of post-emergent applications to grass weeds in crops commonly grown in Australia. In all trials, a 25% w/v e.c. formulation of fluazifop-butyl (JF6901) was used. Non-ionic wetting agents 'Agral 60' and 'Agral 90' were added to fluazifop-butyl treatments at the rate of 0.1% a.c. in the spray solution. Standard herbicide treatments used were of commercially available products, e.g. glyphosate as a 36% a.c.

RESULTS AND DISCUSSION

Uptake and rainfastness: Greenhouse studies with C^{14} labelled compound (JF6901 plus 1.0% 'Agral 90') applied to Johnson grass (*Sorghum halepense*) have shown that the uptake of fluazifop-butyl is very rapid. When the plants were rain-washed 1, 4 or 24 hours after chemical application with 10mm simulated rain falling in 3 minutes, a small but consistent portion of fluazifop-butyl remained on the surface, but by 24 hours most of the chemical had penetrated the leaf (Fig. 2). In view of this rapid penetration, most of the chemical is retained by the plant even if 'rain' falls within a short time after application.

Field tests with simulated 'rain' in other countries and Australia further confirmed the greenhouse results. Working with several grasses, including Johnson grass at Griffith, N.S.W., fluazifop-butyl showed considerably greater rainfastness than glyphosate (Fig. 3).

Crop safety: Post-emergence applications of fluazifop-butyl 'over-the-tops' of many broadleaf crops were completely safe even at the very early growth stages of these crops. The highest rates of fluazifop-butyl tested on various cultivars of these crops are presented in Table 1. In addition to these annual crops, the chemical has been found safe on a wide range of perennial crops, applied as directed sprays or over-the-tops of the young plants.

Herbicidal activity: The weed control efficacy of fluazifop-butyl is governed by a number of factors. These include:

- weed species
- growth stage of the weed
- environmental conditions affecting chemical uptake and weed growth.

Weed species sensitivity: In general the *Andropogoneae* are the most sensitive, followed by the *Aveneae* and the *Paniceae* with the most resistant tribes being the *Festuceae* and *Oryzeae*. Under good growing conditions, 0.25 kg ha^{-1} is usually sufficient to control most of the members of the first three tribes, although higher rates are necessary for many individual species within some tribes. Some species such as winter grass (*Poa annua*) and silver grass (*Vulpia bromoides*) are completely tolerant to the chemical. Rate of chemical required also depends upon the competitive nature of the crop, e.g. lower rates are required for lupins, but much higher rates are necessary for onion; a crop with very open canopy.

Growth stage: Optimum growth stage for treatment varies with the growth habit of the plant and its inherent susceptibility to fluazifop-butyl. In the case of "wild" annual grasses it is desirable to apply the herbicide during the

FIGURE 1

Speed of action of fluazifop-butyl

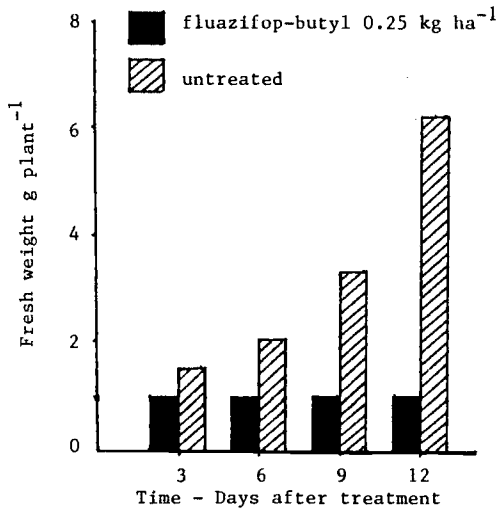

FIGURE 2

Uptake of fluazifop-butyl
at various times after washing

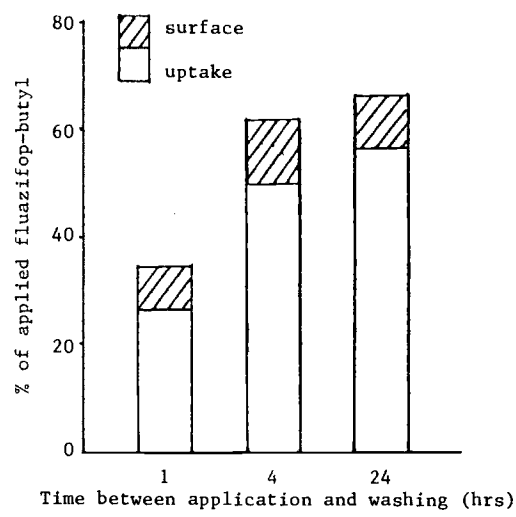

FIGURE 3

Effect of simulated rain falling at various intervals after spraying on efficacy of fluazifop-butyl and glyphosate on Johnson grass and barnyard grass

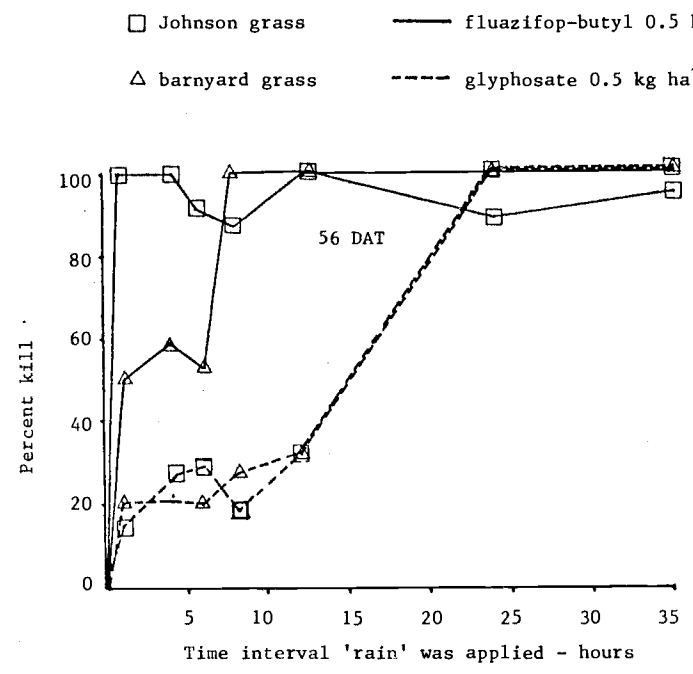

FIGURE 4

Effect of application volume on efficacy of fluazifop-butyl against Wimmera ryegrass and wild oats (28 DAT)

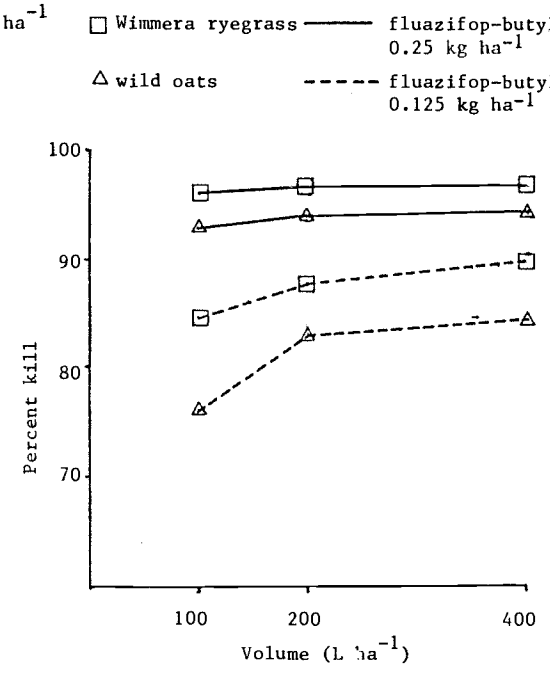

TABLE 1

Maximum safe rates of fluazifop-butyl on various broadleaf crops

Crops	Varieties	Maximum rate tolerated (kg ha^{-1})
Cotton	Namcala	4.0
	Stoneville	4.0
	Delta Pine	4.0
	DP 16	2.0
	DP 61	1.0
Soybean	Bethal	1.0
	Clark 63	1.0
	Forest	1.0
Peanut	Red Spanish	4.0
	White Spanish	4.0
	Virginia Bunch	4.0
Cabbage	Ballhead Hybrid	4.0
Carrot	Topweight	4.0
Clover	Woodgenelup	4.0
Linseed	Glenelg	2.0
	Bonnie Doon	>1.0
Lupin	Unicrop	4.0
	Uniharvest	2.0
Pea	Dunn	4.0
Oilseed rape	Tower	>1.0
	Span	>1.0
Onions	Cream Gold	>4.0
Safflower	Gila	4.0
Sugar beet	Bush MonoG	>1.0
	Sharpes Klein	>4.0
Lucerne	various	3.0

vigorous vegetative stage of establishment before tillering starts. The individual plants should have between two and six leaves and should be from 5 to 10cm tall. Application to the more tolerant species beyond this stage will require higher rates.

On perennial grass species, e.g. couch grass (*Cynodon dactylon*), Johnson grass and Paspalum (*Paspalum dilatatum*), susceptibility is dependent upon environmental conditions and previous cultural practice. All perennial species are much more sensitive if rhizomes and stolons have been thoroughly fragmented and allowed to regrow to 3 to 6 leaves before post-emergence treatment with fluazifop-butyl. The ideal level of fragmentation has not been clearly defined for each species. However, rates of 0.25 to 0.5 kg ha^{-1} have given good control of the above three species in Australia.

Evaluations of fluazifop-butyl on undisturbed, well-established stands of perennial grasses showed that much higher rates of 1.0 to 2.0 kg ha^{-1} were required for good control. In many instances, sequential applications of two half doses spaced 1 to 3 weeks apart have given more consistent control of established stands.

Effect of environment conditions on activity: Environmental conditions can greatly influence the activity of fluazifop-butyl, most notably drought stress or arid conditions (low relative humidity) in irrigated desert agriculture. The symptomology alters from the normal reddish/purple leaf colouration in good growing conditions to more scorch and leaf chlorosis, leading to a yellow leaf colour in dry conditions. The apparent lack of control of top growth is more evident in these dry conditions in that the normal processes of decomposition of dead foliage are not nearly as rapid as under more humid environments.

It appears that under conditions of drought stress or low relative humidity translocation of fluazifop-butyl is severely curtailed, and regrowth from the base of treated stems occurs regularly.

Several additives have been evaluated to try to overcome this effect but with little success. To date the best recommendation is a sequential application applied as near to an irrigation as possible with an interval of 1 to 3 weeks.

Effect of surfactants on activity: Over a wide range of conditions non-ionic surfactant at 0.25% w/v of final spray solutions gives more consistent control than 0.1% w/v, and no real benefit seems to accrue from higher rates than 0.25% w/v. There seems to be very little difference between types of non-ionic surfactants used, see Table 2.

Under more adverse/arid conditions mineral oil/surfactant blends have occasionally given a benefit in quicker, more complete control than 0.25% non-ionic, but this does not appear to be a consistent effect. Rates of crop oil concentrate most generally recommended are 0.5-1.0% v/v of final spray solution.

Table 2. Effect of various surfactants on the weed control efficacy of fluazifop-butyl on wild oats and Wimmera ryegrass (Australia)

Surfactants		Mean percent kill at 28 DAT	
		Wild oat	Wimmera ryegrass
Agral 90	0.1% w/v	75	43
Agral 60	0.1% w/v	65	35
BS 100	0.1% w/v	68	58
Nonidet	0.1% w/v	68	45
Le-Wett	0.1% w/v	68	53
X-77	0.1% w/v	73	58
Abolineum oil	1.0% w/v	73	53

Effect of application volume on activity: At low rates of fluazifop-butyl, e.g. 0.125 kg ha^{-1}, high application volumes of 200 to 400 L ha^{-1} were superior to the lower volume of 100 L ha^{-1} (see Figure 4). At 0.25 kg ha^{-1} application volume did not influence herbicidal efficacy as drastically, although the higher volumes were generally better. The type of wetters and surfactants used under different application volumes had only marginal effects on herbicidal activity. As a general rule as with most post-emergent herbicides, fluazifop-butyl requires good coverage of the target weeds.

Soil degradation and persistence: Fluazifop-butyl is rapidly degraded in moist, coarse sandy loam and coarse sandy soils in under three weeks, and very little remains in soils after an incubation period of twenty-one weeks.

The major degradation product in all cases is the propionic acid, fluazifop. Fluazifop has a half-life of under three weeks or less under moist conditions in most soils but is more persistent in very sandy soils with low organic matter content.

The mobility of fluazifop-butyl and its acid derivative has been determined by thin layer descending chromatography in four different soils. Fluazifop-butyl itself is of low mobility with a peak leaching distance of 3cm or less when leached with 32cm 'rain'. The acid derivative, however, is leached much further and has a mobility of up to twice that of atrazine (which is considered to be moderately mobile in soils).

A trial conducted at Griffith, N.S.W., to measure the persistence of fluazifop-butyl in a clay loam showed that at 1.0 kg ha^{-1} it remained herbicidally active through root uptake for 8 weeks when bioassayed with sorghum, maize and barnyard grass. At 2.0 kg ha^{-1} the chemical persisted for 4 months in the same test.

CONCLUSIONS

Results from a large number of trials from several locations show that fluazifop-butyl can be safely used in many broadleaved crops for the post-emergence control of both annual and perennial grasses. The factors that influence its herbicidal activity appear to be:

- grass species present
- growth stage of grass
- intensity of crop competition
- population density of grass
- environmental conditions
  - soil moisture
  - humidity
  - temperature
- plant conditions:
  - growth rate
  - perennial grasses - degree of stolon/rhizome fragmentation
- other weed control practices.

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