SOIL PERSISTENCE OF PICLORAM IN RELATION TO CLOVER GROWTH

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Summary

The effect of picloram residues in two loam soils on the growth of white (*Trifolium repens*) and red clover (*T. pratense*) in field and pot assays is described. The limited persistence of picloram used in low dosages (less than 2 oz per acre) for selective weed control in certain crops is considered in relation to likely effect on clover growth in a following perennial pasture rotation. Field observations of clover re-establishment on sites treated with picloram for perennial and scrub weed control are discussed.

INTRODUCTION

IN NEW ZEALAND picloram has shown outstanding promise for the control, by both foliar and soil applications, of many hard-to-kill woody weeds such as gorse (*Ulex europaeus*), blackberry (*Rubus fruticosus*), sweet brier (*Rosa rubiginosa*) and broom (*Cytisus scoparius*) (Moffat, 1965), and deep rooted perennial broadleaf plants such as Californian thistle (*Cirsium arvense*) and docks (*Rumex* spp.). The very high activity of picloram to many plant species in relation to most other growth regulatory herbicides is no doubt due in part to its high persistence in soil and plant tissue. Fortunately, this extreme herbicidal potency is balanced by a very low toxicity to mammals, invertebrates and micro-organisms. It appears to be rapidly excreted unchanged in animals and it is not likely to be accumulated in food chain cycles. In any likely crop usage, residues in excess of the standard 1% of the no effect level in long-term chronic toxicity studies are not expected to occur in food for human consumption.

However, although residues of picloram in the environment may not become a toxicological problem to animals, in the soil they could markedly affect the growth and yield of desirable crops and plants. In New Zealand picloram is likely to be applied at much lower rates than other persistent herbicides (0.5 to 4 lb* for industrial and brush control use, and 0.5 to 2 oz for selective crop use) (Mason, 1965, 1966).

Before broadcast applications of picloram can become an established practice, it is necessary to determine the interval between application and acceptable growth of any following crops. In New Zealand this particularly refers to the establishment of pasture legumes following broadcast treatments of picloram. Such applications may have occurred in a preceding field brassica crop (0.5 to 1 oz) or for broadleaf weed control, such as ragwort (*Senecio jacobaea*) in a pasture at 1 to 4 oz, or following brush control during the development of improved pastures. Other picloram-sensitive crops such as tobacco, potatoes, peas, beans or lucerne could be of interest but they are relatively unimportant in comparison with the standard pasture and crop rotations in New Zealand.

* All rates expressed as active ingredient per acre.

The present studies were designed to assess the persistence of picloram or a picloram/2,4-D mixture in loam soils at two locations using white clover (*Trifolium repens*) and red clover (*T. pratense*) as the biological indicator for the presence of picloram or any herbicidally active metabolites. Other possible indicator plants, such as French beans and safflower, were evaluated in preliminary tests but were discarded because of the variability in establishment under the conditions used compared with practicability and local significance of white and red clover. White clover has been established as an extremely sensitive indicator plant for picloram (Newton, 1965). Field observations on the effect of picloram on a range of crops subsequent to treatment will be discussed in relation to the results obtained in experimental studies.

EXPERIMENTAL

The two sites selected for the field residue studies were level areas supporting an improved perennial ryegrass-white clover pasture. The sites were rotary hoed to a depth of three inches, graded and rolled to a uniform, well compacted seedbed. The soil in Trial 1 (Bell Block, Taranaki) consisted of a New Plymouth black loam (Type 67a), grading at six inches to a more compact dull-brown loam subsoil. The soil in Trial 2 (Mangorei Road, Taranaki) consisted of a slightly more porous New Plymouth dark-brown sandy loam (Type 67b) uniform through a nine inch profile and grading below into a dull-brown loam. At this latter site, complete control of all weeds, except clover, was obtained using a preplant soil fumigation of methyl bromide 1 lb per 100 sq. ft. All spray treatments were applied as water-soluble salt formulations to the bare soil under calm conditions to plots 62 ft $\times$ 7 ft using an Oxford Precision Sprayer applying 32 gal per acre. The treatments were non-replicated with 2 ft buffer strips between them. Sub-plots 10 ft long were established across the treated plots in which were drilled three rows of a mixture of white clover and red clover at intervals of 1 day, 1, 2, 3, 4 and 6 months after spraying. At the same time soil cores 1/6 sq. ft in area, 6 in. deep were taken from six random locations down each plot. These cores were divided into two soil depths, 0 to 3 in. and 3 to 6 in., and the two soil samples were potted separately. A mixture of white and red clover was sown into the thoroughly mixed soil, the pots being kept in a frame house and carefully watered overhead as soil moisture conditions demanded. Observations were made for clover survival and vigour of growth one month after sowing, this being sufficient time to allow for full picloram symptoms, or die-off of the seedlings to occur. Qualitative ratings were made on a 0 to 3 scale by two or more independent observers on the six samples from each treatment as follows:

- 0 = No establishment — seedlings germinated and died.
- 1 = Seedlings severely stunted with some mortality after germination. Symptoms of reduced leaf expansion with severe cupping and with a tendency to chlorosis.
- 2 = 100% establishment but seedlings showing slight to moderate leaf cupping with some reduction in growth.
- 3 = Normal growth with no symptoms of reduced leaf expansion.

For practical purposes, a mean rating of 2.5 or above indicates a normal bulk of leaf and stem tissue of clover has developed.

TABLE 1: CLOVER GROWTH IN RELATION TO SOIL CHEMICAL TREATMENT AND ELAPSED TIME,
TRIAL 1, BELL BLOCK, TARANAKI

Treatment (oz)	Sample Depth (in.)	Time After Treatment (Months)				
		1 6.73*	2 8.78*	3 16.90*	6 30.83*	7½ 35.36*
Picloram 0.5	0-3 3-6	2.1 (2.8)† 2.2	2.3 (3) 2.4	2.4 2.5	2.8 (3) 3	2.9 2.8
Picloram 1	0-3 3-6	1.7 (2.4) 2.3	2.2 (2.3) 2.4	2.0 2.4	2.9 (3) 2.8	2.8 2.8
Picloram 2	0-3 3-6	1.5 (2.2) 2.3	1.9 (2.0) 1.9	1.9 2.2	2.8 (3) 2.8	2.8 2.9
Picloram 4	0-3 3-6	0.4 (0.9) 1.9	1.5 (1.2) 1.7	1.5 2.0	3 (3) 2.8	2.6 2.4
Picloram 8	0-3 3-6	0.5 (0) 1.2	0.8 (0.5) 1.4	1.0 1.5	2.7 (3) 2.4	2.6 2.7
Picloram 8/2,4-D 32	0-3 3-6	0 (0) 1.0	0.5 (0.4) 0.1	1.0 1.2	2.1 (3) 2.3	2.7 2.5
Dicamba 8	0-3 3-6	2.3 (2.8) 2.1	2.3 (2.6) 2.6	2.4 2.2	2.9 (3) 3	2.8 2.8
Control	0-3 3-6	2.3 (3) 2.3	2.6 (3) 2.8	2.8 2.8	2.8 (3) 2.9	3 2.9

* Accumulated rainfall in inches.

† Field ratings for growth of clover sown on site in parentheses.

TABLE 2: CLOVER GROWTH IN RELATION TO PICLORAM TREATMENT AND ELAPSED TIME,
TRIAL 2, MANGOREI ROAD, TARANAKI

Treatment (oz)	Sample Depth (in.)	1 day 0*	Time After Treatment (Months)			
			1	2	3	4
Picloram 0.5	0-3 3-6	1.6 (1.7)† —	2.2 2.1	2.3 2.3	2.3 2.3	2.5 2.7
Picloram 1	0-3 3-6	1.1 (0.1) —	0.8 1.1	1.4 1.6	1.4 1.6	2.1 2.0
Picloram 2	0-3 3-6	0.8 (0.3) —	1.1 1.4	1.9 2.0	1.9 2.0	2.4 2.2
Picloram 4	0-3 3-6	0.6 (0) —	0.5 0.8	1.1 1.0	1.1 1.0	1.3 1.4
Picloram 4/2,4-D 16	0-3 3-6	0.2 (0.2) —	0.7 1.1	1.6 2.3	1.6 2.3	2.2 2.4
Control	0-3 3-6	2.2 (2.1) —	2.4 2.3	2.5 2.6	2.4 2.5	2.5 2.6

* Accumulated rainfall in inches.

† Field ratings for growth of clover sown on site in parentheses.

RESULTS AND DISCUSSION

The results of the experiments for the two sites are presented in Tables 1 and 2, both for clover growth in the pot analyses and in the field trials in relation to chemical treatments and soil sample depth. A graphical representation of the general results from Trial 1 are depicted in Fig. 1.

All picloram treatments on both sites have remained toxic to white and red clover for at least one month after treatment, there being no practical difference detectable in response of the two clovers. At the lower rates (2 oz or less) the growth of the

Fig. 1: Clover growth in relation to picloram treatment and elapsed time, Trial 1.

clover sown in the field has been less inhibited than that in the pot assay test, suggesting some dispersion of the residues, possibly by leaching from the surface soil. Below 1 oz, picloram has not maintained its clover inhibitory effect in the pot assay test beyond three months. The comparative treatment as a standard of dicamba 8 oz has been even less persistently toxic to clover than 1 oz picloram. At the higher rates of picloram, the persistency of effect on clover growth is much greater. In Trial 1 the loss in the effect of picloram seems greater but this could be related to the greater exchange and water-holding capacity of the soil and to the higher rainfall occurring on Site 1. Furthermore, in Trial 1, in the absence of pre-treatment soil fumigation a heavy stand of broadleaf weed growth, mainly *Plantago lanceolata*, developed which was absent from Site 2. The reduced availability of the picloram resulting from its uptake by tolerant plants, especially grasses, is likely to reduce its concentration remaining in the soil. In this respect, application of picloram to bare soil in the present tests, without any interception of the spray by the foliage, is considered to be a severe test of soil contamination which is not likely to be experienced in field application.

From the results in Trial 1, a breaking point in the residual toxicity of picloram at 4 and 8 oz towards the clover has occurred at about the six-month level, this being approached by the 2 oz rate after four months in Trial 2.

The comparatively high rainfall experienced in both trials has probably aided the dispersion of the picloram through the soil profile by removing it from the surface. This effect has probably been more pronounced than that likely to be found on soils higher in adsorptive colloids or under lower rainfall conditions such as commonly are found on the eastern parts of the North and South

Islands. The commercial available picloram/2,4-D mixture was included in the trials to determine if potentiation for more rapid breakdown by micro-organisms of picloram might occur in the presence of 2,4-D. In Trial 1 at the 8 oz rate of picloram, no increase in clover growth occurred in the presence of the 2,4-D at any sampling. At the 4 oz rate of picloram in Trial 2, there has been a trend established in the two months' samples onwards for greater clover growth in the mixture than in the equivalent straight picloram treatment. However, more critical laboratory studies will be necessary to establish a soil enrichment effect from the presence of phenoxy compounds in aiding the more rapid breakdown of picloram as has been indicated for dicamba/2,4-D mixtures (Zick, pers. comm.).

Field evidence has shown that white clover will re-establish after 5 months in sites spot treated for ragwort control with 1 lb picloram + 2,4-D, but picloram persistence in relation to the nature of the soil type, rainfall pattern and required pasture cover requires much more specific definition in relation to dosage in brush weed control studies.

Field observations in scrub weed and brassica crop sites have indicated that white and red clover appear to be more tolerant of picloram than subterranean clover (*Trifolium subterraneum*). However, after six months an autumn germination of subterranean clover has survived with only moderate symptoms on a Canterbury broom site treated in the late spring with 0.75 lb picloram plus 2,4-D.

No attempt in the present tests has been made to establish the methods of deactivation or the metabolites resulting from breakdown of the picloram. These need to be the subject of separate investigations. Like most soil-applied pesticides, picloram is subject to inactivation by adsorption, which for picloram is greatest in soils high in organic matter and clays rich in hydrated iron and aluminium oxides (laterites). Frequent rain leaching through sandy soils removes picloram from the soil surface. Deactivation of picloram by plants, by soil micro-organisms and by photochemical degradation in sunlight and ultra-violet light all undoubtedly occur. The soil fungus *Aspergillus niger*, which dechlorinates phenoxyacetic acid herbicides, has been stated by Arnold *et al.* (1966) to slowly degrade picloram. Whatever the methods involved, picloram is undoubtedly deactivated and an estimate of its half-life for different soils has already been made (Goring *et al.*, 1965).

CONCLUSIONS

From field experience, it is not expected that low rates of picloram (less than 2 oz) which have been used experimentally for selective broadleaf weed control in field brassica crops, cereals and linseed are likely to lead to serious problems in the establishment of clovers in subsequent perennial pastures. Any remaining soil residues of picloram still present six months after treatment when the pasture has been sown down have been adequately dissipated by thorough cultivation. However, it may be advisable to avoid in the rotation immediately following the picloram treatment such highly sensitive crops as tobacco, beans and tomatoes, and also possibly peas and potatoes. It is doubtful that yearly applications of such crop-selective dosages of picloram will accumulate in these soils.

The problem of soil residues resulting from higher rates of picloram used in brush weed control programmes (up to 4 lb in broadcast treatments) has not been clarified by the present short-

term preliminary studies. Until the fate of pasture legumes establishment is known in sites treated with picloram at more than half a pound per acre, spot treatments are recommended only, except for non-cropping land.

Picloram is certainly more hazardous in its persistence in the soil than many other residual herbicides. But considering its much lower use dose, it should not constitute "a problem child" in the agricultural environment if used as recommended and with care appropriate for a herbicidal compound of such outstanding potential in New Zealand agriculture.

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