A REVIEW OF SOME FACTORS AFFECTING THE PERFORMANCE OF GLYPHOSATE

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Summary

Glyphosate offers good control of a broad spectrum of annual, biennial and perennial herbaceous weeds. It is a post-emergence, foliar absorbed herbicide which translocates and destroys all parts of herbaceous plants. Correct use of glyphosate, taking into account the factors affecting its performance, will enable the best results to be obtained.

INTRODUCTION

Perennial weeds are an increasingly important problem in many parts of the world today. This is due in part to the increased use of a range of non-selective herbicides which for the last decade have successfully eliminated certain annual and perennial weeds. The majority of those weeds eliminated are characterized by a limited root system.

In New Zealand this practice has led to the establishment and expansion of deep rooted perennials, many of which are capable of regenerating themselves by growing from underground rootstocks. Such species as paspalum (*Paspalum dilatatum*), Mercer grass (*Paspalum paspaloides*), kikuyu grass (*Pennisetum clandestinum*), Indian doab (*Cynodon dactylon*), couch (*Agropyron repens*), Californian thistle (*Cirsium arvense*) and docks (*Rumex* spp.) are already weeds of economic importance in New Zealand. This has also occurred overseas where nutgrass (*Cyperus rotundus*), Johnson grass (*Sorghum halepense*), imperata (*Imperata cylindrica*) and field bindweed (*Convolvulus arvensis*) are troublesome.

Glyphosate, N-(phosphonomethyl) glycine present as the isopropylamine salt, not only exhibits exceptional herbicidal activity but also has the capacity to translocate readily (Baird *et al.* 1971).

It is the intention of this paper to review some of the findings of international researchers, who have tested glyphosate in many weed control programmes, so that a better understanding of this herbicide is obtained for future New Zealand use.

TOXICOLOGY

The isopropylamine salt of glyphosate was found to have an acute oral LD₅₀ of 4900 mg/kg on rats. The acute skin absorption is 7940 mg/kg. Glyphosate produces no apparent skin irritation but formulations are regarded as mild skin and severe eye irritants to rabbits. Additional studies show that wildlife, fish and honey bees are tolerant to glyphosate thus affording a high degree of environmental safety.

Proc. 28th N.Z. Weed and Pest Control Conf.

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MODE OF ACTION

Jaworski (1972) has theorized from limited studies that glyphosate interferes with the biosynthesis of phenylalanine with the metabolism of chorismic acid in the aromatic amino acid biosynthetic pathway. It is also thought that glyphosate may inhibit or repress chlorismatic mutase and/or prephenate dehydratase.

Glyphosate actively translocates from leaf and stem tissue to the underground root system of perennial weeds. Sprankle *et al* (1972, 1973) using Johnson grass and couch in both greenhouse and field studies demonstrated that glyphosate translocates basipetally to the rhizomes and actively growing shoots. Both Lange (1973) and Friesen (1973) determined that this translocation is quite rapid and that the majority of the chemical was moved into the rhizomes within (under normal growing conditions) 24 hours of foliar application.

Much experimental evidence indicates that high humidity and high temperatures a few hours before and after application are most conducive to uptake but the herbicide enters the plant quite slowly. Baird and Begeman (1972) demonstrated that the occurrence of rainfall within eight hours after application reduces activity, the most significant reduction occurs within four hours of application.

At the Weed Research Organisation (WRO), Oxford, a controlled environment study, (humidity 80-90% r.h. with air temperature at 18°C) indicated that over 90% of the glyphosate applied remained on the leaf surface after 24 hours and over 50% was still present after 10 days. These findings suggest that in a number of occasions when acceptable results have been obtained where rainfall has occurred within 10 days of application, that only moderate amounts of glyphosate have actually reached the internal system of the target weeds.

The WRO work also confirms the rapidity of translocation once entry of the chemical is achieved. Their experiments show that at an air temperature of 8°C and soil temperature of 10°C all 16 to 20 buds on the rhizome length of the plant treated accumulated a lethal dose in 24 hours. At an air temperature of 20°C it took only 9 hours.

From the foregoing, it is easy to conclude that in order to utilize all of the glyphosate available to the plant, low diluent volumes (186 litres/ha) would be more conducive to good results than high volumes (1120 litres/ha). This may vary in relation to the density and bulk of the target weeds.

Baird and Begeman (1972) state that glyphosate was less effective at 32°C than at 16°C. Caseley (1973) confirmed this. Caseley postulates that the reduced activity of glyphosate at high temperatures may be due to rapid drying of the spray droplet resulting in reduced uptake. For this reason it has been suggested that night dews after application may be beneficial to the absorption process.

Results from Caseley's work with differing light intensities were not as clear cut. It appeared that low light led to a delay in evidence of herbage damage and toxic activity in the rhizomes. This has been observed on many occasions in the field when glyphosate applications have taken place in cloudy conditions or under full-canopied plantation trees. In these situations weed control is normally comparable to treatments in high levels of sunlight.

RESIDUAL HERBICIDAL ACTIVITY IN SOIL

Studies, by Baird *et al* (1971) showed that no crop damage would result if seeding followed treatment regardless of the time interval. A preliminary test was performed wherein soybeans (*Glycine max*) and maize (*Zea mays*) that were sown into soils of 1% organic content

about 19 hours after application resulted in no herbicidal effects being observed during the growing season. The yields obtained, (Table 1) confirmed the belief that no pre-emergence benefit could be obtained from the use of glyphosate, nor was there any deleterious effect on subsequent germinating plants.

TABLE 1: YIELDS OF CROPS SOWN 19 HOURS FOLLOWING APPLICATION OF GLYPHOSATE TO THE SOIL
(From Baird *et al.* 1971)

Glyphosate	Soybeans	Maize
71.7 kg/ha	3.33	6.52 t/ha
0.0	3.29	5.77

Campbell's (1974) results showed that glyphosate had little or no effect on germination of surface-sown seeds but did have deleterious effects on subsequent establishment and growth of legumes when sown within 14 days of spraying. Subterranean clover (*Trifolium subterraneum*) was more sensitive than lucerne (*Medicago sativa*) to the higher rate (1.5 and 4.5 kg/ha). No deleterious effects have been observed in New Zealand from limited Monsanto sod-seeding tests in Southland when the crop was oversown one day after glyphosate applications. Atkinson (*Pers. comm.*) reports that from observations of his work in direct drilled lucerne and maize, crop vigour was temporarily retarded at about 0 to 14 days after the herbicide application. It was concluded that this phenomenon was due to a temporary nitrogen deficiency during the pasture decay process and it is assumed that Campbell encountered the same problem.

Another factor that should be considered is the harmful effects of treated plant residues in the soil on the growth of other plants. This phenomenon was first reported by Kommedahl *et al.* (1959). Wellbank (1963) confirmed that couch both living and the residues from the dead plants rather severely injure germinating seeds and young seedlings of crop test plants. Friedman and Horowitz (1970) found similar toxin production by the perennials Indian doab, nutgrass, and Johnson grass. Baird (1974) found that barley and wheat were chlorotic and stunted in all treatments when couch and ryegrass, as the target weed species, were controlled by glyphosate. The weed free controls were normal thus posing the possibility of toxin production by the weeds. It is obvious that additional detailed studies in this area of use will be required.

STAGE OF GROWTH

The stage of growth is a factor that will have considerable influence on the success of glyphosate. Co-factors would be cultivation or mowing prior to spraying, time of application and general seasonal growing conditions.

New spring growths of herbaceous perennial weeds are going to afford little leaf surface for absorption of sufficient material to be lethal to a vast subterranean root system. Similarly mowing or cultivation prior to treatment could reduce the success of the treatment.

POST TREATMENT CULTIVATION

Baird and Upchurch (1972) found that complete seed bed preparation (rotocultivator at a 200 mm depth) at 0 to 7 days following

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application did reduce activity. However they suggest that cultivation at 8 to 21 days after treatment did not materially reduce control as observed 22 weeks after treatment.

In conclusion glyphosate offers a great deal; good control of a broad spectrum of annual, biennial and perennial weeds. It is a post emergence, foliar absorbed herbicide which translocates and destroys all parts of herbaceous plants.

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