A PRELIMINARY REPORT ON BENEFIN — AN ANALOG OF TRIFLURALIN

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BENEFIN (*N*-butyl-*N*-ethyl-*a,a,a*-trifluoro-2,6-dinitro-*p*-toluidine) is a pre-emergent, soil incorporated, selective herbicide that is a close analog of trifluralin (*a,a,a*-trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine). From a slight change in chemical structure, with benefin having butyl and ethyl substituents in the amine function in place of the two propyl substituents found in trifluralin, benefin demonstrates much greater safety in a few crop species with only a slight reduction in overall herbicidal activity.

General characteristics of benefin can best be illustrated by direct comparison with trifluralin:

	<i>Benefin</i>	<i>Trifluralin</i>
Acute Oral L.D.0 for adults rats	>10,000 mg/kg	>10,000 mg/kg
Solubility in H ₂ O	70 ppm (25°C)	<1 ppm (27°C)

Both compounds are susceptible to degradation by ultraviolet irradiation, volatilization and microbial decomposition.

Research findings have shown that most of the knowledge concerning the behaviour of trifluralin can also be applied to benefin. No trifluralin metabolites have been found in plant tissues. Carbon-14 studies revealed that radioactive CO₂ was produced by the plant and soil. In mature plants and seeds, radioactivity was uniformly distributed in carbohydrates, proteins, fat and cell wall components.

As previously mentioned, ultraviolet irradiation, volatilization and microbial decomposition all contribute to the disappearance of both herbicides from soil. The first two losses can be minimized by mechanical incorporation into the soil immediately after the application. This facet will be dealt with later in this paper.

Volatilization from soil surfaces is influenced by soil temperature, type and moisture in addition to the herbicide concentration. Most of the loss is experienced during the first few hours after application. The more adsorptive soils show the greatest retention of these two chemicals.

The speed of photodecomposition increases when benefin or trifluralin is exposed on smooth surfaces but is reduced when exposed on soil surfaces.

Although microbial decomposition plays an important rôle in the gradual disappearance of these herbicides once they have been incorporated into the soil, no one organism or group of organisms responsible for microbial breakdown has yet been isolated. This method of decomposition is directly influenced by soil moisture, temperature and percentage organic matter content.

Benefin and trifluralin are strongly adsorbed by the component soil fractions and thus are highly resistant to leaching processes.

* Benefin (a product of Elanco Products Co., a division of Eli Lilly and Co., Indianapolis, Indiana, U.S.A.) is the common (generic) name accepted by the Weed Society of America.

This adsorption does not render either herbicide unavailable for activity against susceptible weed seedlings; however, adsorption on organic matter seems to restrict herbicidal activity.

Both of these herbicides are active only as pre-emergent materials and must come in contact with the developing root system of the susceptible weed species to effect control. Because of this and the information just discussed concerning its relationship with soil, benefin (again, like trifluralin) must be thoroughly incorporated with the soil within the zone containing weed seeds, to ensure consistent, dependable weed control. Once this incorporation has been accomplished, there is no dependence on subsequent weather conditions, including temperature and rainfall, that might greatly influence the dependability of surface applied herbicides.

Suggested tools to accomplish this soil incorporation would include power-driven rotary hoes (cultivators), disc harrows (2 tines at right-angles), bed conditioners (Do-All), rolling cultivators (ground-driven), etc. *Power-driven equipment is not essential* but good adjustment of the chosen tool is. The soil texture, ease of tillage and its physical condition will dictate the type of implement required to *move the chemical effectively* to a depth of 2 to 3 in. Implements such as discs must be set to cut 4 to 6 in. to achieve this degree of herbicide movement. Either excessively shallow or deep incorporation should be avoided since they both can lead to erratic weed control.

As with trifluralin, benefin is formulated as an emulsifiable concentrate. Granular formulations are currently being evaluated. Suggested soil incorporated rates in lb a.i. per acre are as follows:

Soil	Benefin	Trifluralin
Sand, sandy loam	0.75	0.50
Loam	1.00	0.75
Silt or clay	1.50	1.00
10-15% organic*	2.00-3.00	1.50
15% + organic*	4.00	2.00

* Suggested only as preliminary trials.

Recommended volume of total liquid per acre is 10 to 40 gal or more.

Trifluralin is registered in the U.S.A. and other countries such as South America, Central America, Mexico, Australia, South Africa, etc.; and is being used on a commercial scale in many crops that would include:

Applications prior to Seeding	Applications prior to Transplanting
cotton	tomatoes
soybeans	peppers
safflower	broccoli
dry beans (navy)	Brussels sprouts
southern peas	cabbage
snap (green) beans	cauliflower
lima beans	citrus seedlings
okra	grape rootings
castor beans	nursery stock liners of various
	ornamentals

Crops being investigated for registration (trifluralin) are as follows:

<i>Prior to Seeding</i>	<i>Established Crops</i>	<i>Prior to Transplanting</i>	<i>After Crop Emergence</i>
celery carrots garlic (cloves) onions (sets)	vineyards orchards lucerne (alfalfa) clovers	fruit trees nut trees celery carrots	cucurbits (melons, etc.) onions potatoes (Irish) sugar beets

Benefin is currently being used only on established turf grasses. However, greenhouse and field efforts have provided encouraging data that will allow for registration application for the following crops prior to seeding: Lettuce; alfalfa (lucerne); red clover; peanuts (Virginia and Spanish types). Benefin has also given initial indications of selectivity when applied prior to seeding to: Potatoes (Irish); cucurbits (melons, etc.); cole crops (cabbage, cauliflower, etc.); tobacco (transplants); peas.

The spectrum of weed species that are susceptible to both trifluralin and benefin at the recommended soil-incorporated rates are as follows:

<i>Grasses</i>	<i>Broadleaves</i>
<i>Echinochloa crusgalli</i> (L.) Beauv.	<i>Amaranthus palmeri</i> S. Wats.
<i>Poa annua</i> L.	<i>Mollugo verticillata</i> L.
<i>Brachiaria</i> spp.	<i>Stellaria media</i> (L.) Cyrill.
<i>Bromus tectorum</i> L.	<i>Richardia scabra</i> L.
<i>Bromus secalinus</i> L.	<i>Chenopodium</i> spp.
<i>Digitaria</i> spp.	<i>Polygonum</i> spp.
<i>Dactyloctenium aegyptium</i> (L.) Richter	<i>Kochia scoparia</i> (L.) Schrad.
<i>Setaria</i> spp.	<i>Chenopodium album</i> L.
<i>Eleusine indica</i> (L.) Gaertn.	<i>Urtica urens</i> L.
<i>Sorghum halepense</i> (from seed)	<i>Amaranthus</i> spp.
<i>Echinochloa colunum</i> L.	<i>Tribulus terrestris</i> L.
<i>Panicum dichotomiflorum</i> Mich.	<i>Portulaca oleracea</i> L.
<i>Panicum texanum</i> Buckl.	<i>Salsola kali</i> L. var. <i>tenusifolia</i> Tausch.
<i>Cenchrus</i> spp.	
<i>Sorghum vulgare</i> Pers.	
<i>Leptochloa</i> spp.	
<i>Eragrostis cilianensis</i> (All.) Lutati	
<i>Panicum capillare</i> L.	

Established weeds are tolerant to benefin as they are with trifluralin. All herbicidal activity is pre-emergent. Other weed genera and species than those above will be observed to be susceptible to both herbicides as their use diversifies to even more geographical areas. The writer invites substantiated reports of such findings.

Benefin and trifluralin have opened a new horizon in selective, pre-emergent weed control. The interacting facets of soil incorporation, resistance to leaching, and the elimination of dependence upon a specific type of weather for effective herbicide performance have made these two chemicals number one candidates for the control of the many weed species in all of the crops listed above.