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# Isoxaben

**BROAD SPECTRUM HERBICIDE  
FOR TREE NUT ORCHARDS AND VINEYARDS**

## **Global Technical Bulletin**





## Overview

Isoxaben is a member of the benzamide herbicide family that can be used for preemergence control of broadleaf weeds in both bearing and non-bearing tree nut orchards and vineyards. Isoxaben is unique as the only herbicide used in tree nut orchards and vineyards that is a cellulose biosynthesis inhibitor (CBI) mode of action, making it an integral component in herbicide programs for managing herbicide-susceptible and herbicide-resistant broadleaf weeds. Isoxaben should be used in herbicide rotation programs with other tree nut and vineyard herbicides. The broad spectrum, preemergence residual activity of isoxaben, with proven safety to crops, allows isoxaben to be used to control important weeds in bearing and non-bearing tree nut orchards and vineyards. Isoxaben can be used to control susceptible and glyphosate-resistant broadleaf weeds found in these crops.

Isoxaben provides preemergence, residual herbicidal activity at use rates from 560 to 1120 grams active ingredient/hectare (0.5 to 1.0 lb ai/acre). When applied in the winter dormant season for control of winter annual broadleaf weeds, isoxaben may provide up to 6 months residual weed control of susceptible broadleaf weeds.

Isoxaben, alone, will control important tree nut orchard and vineyard weeds such as marestalk/horseweed (*Coryza canadensis*), hairy fleabane (*Coryza bonariensis*), mallow/cheeseweed (*Malva* spp.), filarees (*Erodium* spp.), Shepherd's purse (*Capsella bursa-pastoris*), henbit (*Lamium amplexicaule*), common chickweed (*Stellaria media*), London rocket (*Sisymbrium irio*), and sowthistle (*Sonchus* spp.).

With the expanded registration in bearing tree nut orchards and vineyards, isoxaben premix concepts are being developed. Along with other commercially available tree crop and vineyard herbicides, isoxaben premixes will provide an even wider spectrum of broadleaf residual weed control, utilizing the power of multiple modes of action to manage weeds in orchards and vineyards.

For country specific recommendations and additional information please consult a product label and/or contact your local Dow AgroSciences representative.

## Noteworthy Features

- **Preemergence Control.** Excellent preemergence control of a wide spectrum of broadleaf weeds in vineyards and tree nut orchards when compared to currently registered herbicides, including glyphosate-resistant and susceptible marestalk (horseweed) and hairy fleabane.
- **Residual Control.** Up to 6 months residual control of susceptible weeds, depending on use rate and environmental conditions, providing for a reduced number of herbicide applications per season.
- **Flexible Application Timing.** Applied preemergence, prior to weed germination at any time of the year, subject to PHI (pre-harvest interval) restrictions.
- **Tank Mix Compatibility.** No compatibility issues when mixed with other commonly used tree nut and vineyard pesticides, growth regulators and/or nutrients.
- **Tank Mix Flexibility.** Isoxaben can be tank mixed with postemergence, burndown herbicides such as glyphosate, glufosinate and paraquat to provide burndown activity on existing weeds. Isoxaben can be tank mixed with preemergence grass herbicides such as oryzalin or pendimethalin for broad spectrum, residual control of grass weeds.
- **Moderate Use Rates.** Isoxaben use rates vary from 560 to 1120 grams ai/hectare (0.5 to 1.0 lb ai/acre) depending on the target weed and the desired length of residual broadleaf weed control. The residual weed control provided by isoxaben results in a reduction in environmental herbicide loading in tree nut orchards and vineyards when compared to current programs involving multiple herbicide applications per year.
- **Crop Tolerance.** Excellent tree nut and grapevine tolerance when applied at recommended use rates and application timings.
- **Environmental and Toxicological Profile.** Isoxaben possesses favorable environmental and toxicological profiles.



# Biological Activity

## Weed Control

Isoxaben provides broad spectrum, preemergence control of many winter and summer annual broadleaf weeds in tree nut orchards and vineyards. Isoxaben has no appreciable grass weed control activity and should be tank mixed with an approved preemergence grass herbicide such as oryzalin or pendimethalin for residual control of grass weeds. Isoxaben has no appreciable postemergence weed control activity and must be tank mixed with an approved postemergence burndown herbicide such as glyphosate, glufosinate or paraquat to control existing weeds at the time of application.



Isoxaben premixes are being developed for use in tree nut orchards and vineyards. These premixes will provide broader spectrum weed control, with multiple modes of action, to help reduce the development of herbicide resistance. Premixes can provide up to 6 months of weed control to susceptible weeds, reducing the number of herbicide applications needed.

A key attribute of isoxaben is the excellent preemergence, residual weed control activity of glyphosate-susceptible and resistant marestail/horseweed (*Conyza canadensis*) and hairy fleabane (*Conyza bonariensis*). Isoxaben also provides residual control of many other commercially important broadleaf weeds in tree nut orchards and vineyards.

The following table provides a listing of commercially important weed species that have been found to be susceptible, moderately susceptible or tolerant to isoxaben. For country specific recommendations and additional information, please consult a product label and/or contact your local Dow AgroSciences representative.

**These tables should only be used as guides. They are not an endorsement of weed control.**

Susceptible			
<i>Amaranthus</i> spp.	<i>Conyza bonariensis</i>	<i>Lactuca serriola</i>	<i>Raphanus raphanistrum</i>
<i>Ambrosia</i> spp.	<i>Conyza canadensis</i>	<i>Lamium amplexicaule</i>	<i>Rumex acetosella</i>
<i>Amsinckia menziesii</i>	<i>Conyza ramosissima</i>	<i>Lepidium virginicum</i>	<i>Salsola tragus</i>
<i>Anthemis cotula</i>	<i>Cyclosporum leptophyllum</i>	<i>Malva</i> spp.	<i>Sinapis arvensis</i>
<i>Aster</i> spp.	<i>Daucus carota</i>	<i>Matricaria discoidea</i>	<i>Sisymbrium irio</i>
<i>Brassica</i> spp.	<i>Descurainia pinnata</i> spp. <i>brachycarpa</i>	<i>Mellilotus officinalis</i>	<i>Solanum nigrum</i>
<i>Calandrinia ciliata</i>	<i>Eclipta prostrata</i>	<i>Oxalis stricta</i>	<i>Sonchus</i> spp.
<i>Capsella bursa-pastoris</i>	<i>Erodium cicutarium</i>	<i>Physalis angulata</i>	<i>Stellaria media</i>
<i>Cardamine</i> spp.	<i>Gamochaeta purpurea</i>	<i>Phytolacca americana</i>	<i>Taraxacum officinale</i>
<i>Cerastium vulgatum</i>	<i>Geranium carolinianum</i>	<i>Plantago</i> spp.	<i>Trifolium repens</i>
<i>Chamaesyce maculata</i>	<i>Hydrocotyle</i> spp.	<i>Polygonum</i> spp.	<i>Veronica</i> spp.
<i>Chenopodium album</i>	<i>Ipomoea hederacea</i>	<i>Portulaca oleracea</i>	

Moderately Susceptible			
<i>Anagallis arvensis</i>	<i>Datura stramonium</i>	<i>Ipomoea purpurea</i>	<i>Picris echioides</i>
<i>Carduus nutans</i>	<i>Epilobium brachycarpum</i>	<i>Kochia scoparia</i>	<i>Polygonum argyrocoleon</i>
<i>Chenopodium murale</i>	<i>Erodium moschatum</i>	<i>Medicago lupulina</i>	<i>Richardia scabra</i>
<i>Convolvulus arvensis</i>	<i>Eupatorium capillifolium</i>	<i>Medicago polymorpha</i>	<i>Rumex crispus</i>
<i>Coronopus didymus</i>	<i>Euphorbia</i> spp.	<i>Mollugo verticillata</i>	<i>Senecio vulgaris</i>
<i>Croton setigerus</i>	<i>Helianthus</i> spp.	<i>Oenothera</i> spp.	<i>Urtica urens</i>
<i>Cynanchum laeve</i>	<i>Hibiscus trionum</i>	<i>Oxalis corniculata</i>	<i>Vulpia myuros</i>

Tolerant			
<i>Avena fatua</i>	<i>Cyperus esculentus</i>	<i>Panicum</i> spp.	<i>Sorghum halepense</i>
<i>Bromus</i> spp.	<i>Digitaria</i> spp.	<i>Poa annua</i>	
<i>Cynodon dactylon</i>	<i>Hordeum</i> spp.		





*Conyza canadensis* (Marestail/Horseweed)



*Conyza bonariensis* (Hairy Fleabane)



*Malva neglecta* (Common Mallow)



*Stellaria media* (Common Chickweed)



*Erodium cicutarium* (Redstem Filaree)



*Lamium amplexicaule* (Henbit)

## Herbicidal Activity

Susceptible broadleaf weeds treated preemergence with isoxaben will typically not emerge from the soil. Susceptible weeds show reduced emergence following preemergence applications of isoxaben dependent on herbicide rate, activation from moisture and time after application. Susceptible broadleaf weeds growing in treated soil generally display symptomology similar to that of dinitroaniline herbicides. Isoxaben should be used in combination with other herbicides for preemergence control of grass weeds and mixed with a suitable postemergence herbicide to control existing emerged weeds.

Isoxaben has virtually no activity when applied as a foliar treatment, except on some species from the *Brassicaceae* family and certain highly susceptible ornamentals. Isoxaben is absorbed into the roots of susceptible weeds from the soil solution, and penetration into leaves is limited.

No isoxaben-resistant weed biotypes have been identified.

## Crop Tolerance

Isoxaben has limited soil movement properties from a preemergence application. Non-bearing and bearing tree nut and vine crops have demonstrated excellent tolerance to preemergence applications of isoxaben. Isoxaben is not volatile and will not move off soil to injure tree nut and vine crops. For country specific recommendations and additional information please consult a product label and/or contact your local Dow AgroSciences representative.



## Mode of Action

Isoxaben belongs to the Benzamide family of herbicides and inhibits cellulose biosynthesis in the cell walls of susceptible weeds (WSSA group 21). This means that cells cannot divide during the reproductive cycle; therefore, they cannot grow, causing death. While cell division does not occur, this mode of action should not be confused with mitotic inhibition that occurs with dinitroaniline herbicides.

## Symptomology

As a preemergence herbicide, isoxaben inhibits germination and growth of susceptible broadleaf weeds. As susceptible weed seeds germinate, isoxaben prevents growth by interfering with cellulose biosynthesis. Plant growth is stopped and the seedlings gradually die.

Susceptible broadleaf weeds will not usually emerge from the soil after being treated with efficacious rates of isoxaben. Susceptible broadleaf weeds growing in treated soil generally display symptomology similar to that of dinitroaniline herbicides. These symptoms include:

- o Growth inhibition (stunting)
- o Reduced root growth
- o Root clubbing (swelling of meristemic and elongation zones)
- o Root hair distortions

## Absorption/Translocation

Isoxaben is absorbed into the roots of susceptible weeds from the soil solution via the process of passive diffusion. It is absorbed by roots of germinating seedlings and translocated to stem and leaf tissues. Isoxaben must be activated by rainfall or sprinkler irrigation. After activation, isoxaben remains near the soil surface. Penetration into leaves is limited.

Root and shoot development is disrupted. Germinating seedlings appear unable to take up water. Susceptible weeds do not normally emerge.

## Formulations

Isoxaben is currently available as GALLERY® T&V 75WDG herbicide. This formulation contains 75% active ingredient (750 grams ai/kg) isoxaben. Premix formulations of isoxaben are being developed with other Dow AgroSciences active ingredients to meet the multiple needs of tree nut orchards and vineyards. Formulated products must be mixed in water and should be applied with a burndown tank mix partner to control emerged weeds. For country specific recommendations and additional information, please consult a product label and/or contact your local Dow AgroSciences representative.

## Registrations

Isoxaben is currently registered in the United States for use in non-bearing tree nut orchards and vineyards as well as for broadleaf weed control in turf and ornamentals.

## Soil Behavior

Isoxaben is moderately persistent in soil under normal field conditions with half-lives in the range of 30-300 days (average ~ 120 days). Isoxaben is less persistent under anaerobic conditions with a half-life of approximately 3 days in flooded soil. Degradation of isoxaben in the soil and water environment is driven by a combination of microbial degradation and photodegradation by sunlight. Isoxaben is moderately mobile in soil with an average organic carbon adsorption coefficient ( $K_{oc}$ ) of approximately 350 L/kg. The potential for groundwater and surface water contamination is low under typical use conditions.

## Non-Target Plants

Isoxaben is primarily a preemergence herbicide with little to no postemergence herbicidal activity; hence, no injury is expected to most non-target crops. Certain species in the *Brassicaceae* family and certain ornamentals are susceptible to foliar applications of isoxaben and could potentially be injured from off-target drift. Tank mix partners with isoxaben must be considered for overall crop tolerance and drift concerns. Some rotational crops may be injured, especially *Brassica* species if planted immediately following the treated crop; be certain to consult the label for the correct rotational crop restrictions following an application of isoxaben or an isoxaben-containing premix.

## Non-Target Arthropods & Bees

Isoxaben has been shown to have low toxicity to bees, parasitic wasps and predatory mites in laboratory studies.



## Toxicology

	Test Species	Toxicity Parameters
<b>Mammalian</b> Studies have shown that isoxaben is not carcinogenic, teratogenic, mutagenic or a reproductive hazard.	Acute Oral, rat	> 10,000 mg/kg
	Acute Oral, mouse	> 10,000 mg/kg
	Acute Oral, dog	> 5,000 mg/kg
	Acute Dermal, rabbit	> 2,000 mg/kg
	Acute Dermal, rat	> 2,000 mg/kg
	Acute Inhalation, rat	LC <sub>50</sub> > 2.68 mg/L
	Primary Dermal Irritation, rabbit	Not a dermal irritant
	Primary Eye Irritation, rabbit	Slight eye irritation
	Dermal Sensitization Potential, guinea pigs	Not skin sensitizer
	Mutagenicity Tests (Ames Test, unscheduled DNA synthesis, DNA repair assay, CHO-HGPRT chromosome aberration test in CHO cells, micronucleus, assay mouse lymphoma assay, and mouse micronucleus)	Negative
	Teratogenicity, rat	NOAEL: >1000 mg/kg/d, dam and litter





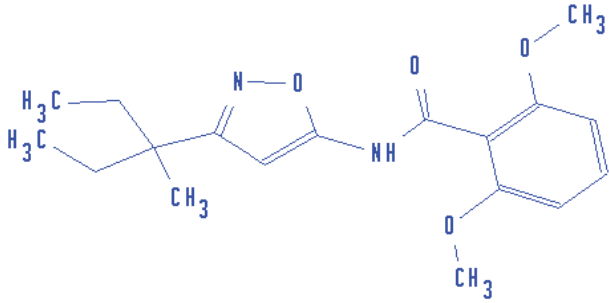
<b>Mammalian</b> (continued)	Teratogenicity, rabbit	NOAEL: 320 mg/kg/d dam; >1000 mg/kg/d litter
	3 Generation Reproduction Toxicity, rat	NOAEL: 40 mg/kg/d parent; 200 mg/kg/d offspring
	2-yr Dietary Chronic, rat	NOAEL = 51 mg/kg/d
	2-yr Dietary Chronic, mouse	NOAEL = 114 mg/kg/d
	1-yr Dietary Chronic, dog	NOAEL = 100 mg/kg/d
<b>Birds</b> Practically non-toxic	Bobwhite Quail <i>Colinus virginianus</i>	14 day LD <sub>50</sub> > 2000 mg/kg body weight
	Bobwhite Quail <i>Colinus virginianus</i>	8 day dietary LC <sub>50</sub> >5000 ppm diet
	Mallard Duck <i>Anas platyrhynchos</i>	8 day dietary LC <sub>50</sub> >5000 ppm diet
<b>Fish</b>	Bluegill Sunfish <i>Lepomis macrochirus</i>	96 hr LC <sub>50</sub> ≥ 1.1 mg/L
	Rainbow Trout <i>Salmo gairdneri</i>	96 hr LC <sub>50</sub> ≥ 1.1 mg/L
	Sheepshead Minnow <i>Cyprinodon variegates</i>	96 hr LC <sub>50</sub> ≥ 0.87 mg/L
	Japanese Carp <i>Cyprinus carpio</i>	96 hr LC <sub>50</sub> ≥ 1.1 mg/L
	Fathead Minnow <i>Pimephales promelas</i>	33 day NOEC ≥ 0.40 mg/L
<b>Freshwater invertebrates</b>	Quahog clam <i>Mercenaria mercenaria</i>	96 hr EC <sub>50</sub> > 0.96 mg/L
	Crustacean Waterflea <i>Daphnia magna</i>	48 hr LC <sub>50</sub> > 1.3 mg/L

<b>Saltwater invertebrates</b>	<i>Grass shrimp</i> <i>Palaemonetes pugio</i>	96 hr LC <sub>50</sub> > 1.0 mg/L
<b>Algal growth</b>	Freshwater diatom <i>Navicula pelliculosa</i>	72 h EC <sub>50</sub> > 86 mg/L
	Freshwater Green Algae <i>Selanastrum capricornutum</i>	14 d EC <sub>50</sub> > 1.4 mg/L
<b>Aquatic Plant</b>	Duckweed <i>Lemna gibba</i>	14 d EC <sub>50</sub> = 0.013 mg/L
<b>Bees</b> Practically non-toxic	Honeybees <i>Apis mellifera</i>	96 hr LD <sub>50</sub> > 100 µg/bee
<b>Beneficial Arthropods</b> Harmless to arthropods	Predatory mite <i>Typhlodromus pyri</i>	LR <sub>50</sub> > 1000 g/ha
	Parasitic wasp <i>Aphidius phopalosiphi</i>	LR <sub>50</sub> > 1000 g/ha
<b>Earthworms</b> Practically non-toxic	Earthworm <i>Eisenia foetida</i>	14 d LC <sub>50</sub> > 100 mg/kg.





## Description of Chemistry

<b>COMMON NAME:</b>	isoxaben
<b>CAS NUMBER:</b>	82558-50-7
<b>CODE NAMES TESTED:</b>	EL-107, K-329195, LY-121607
<b>CHEMICAL NAME (CAS):</b>	N-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide
<b>CHEMICAL NAME (IUPAC):</b>	N-[3-(1-ethyl-1-methylpropyl)isoxazol-5-yl]-2,6-dimethoxybenzamide
<b>CHEMICAL STRUCTURE:</b>	
<b>CHEMICAL FAMILY:</b>	Benzamide
<b>EMPIRICAL FORMULA:</b>	C <sub>18</sub> H <sub>24</sub> N <sub>2</sub> O <sub>4</sub>
<b>MOLECULAR WEIGHT:</b>	332.39
<b>RELATIVE DENSITY (SPECIFIC GRAVITY):</b>	1.19 g/mL
<b>MELTING POINT:</b>	348 – 354°F (176 – 179 °C)
<b>VAPOR PRESSURE:</b>	< 3.9 X 10 <sup>-7</sup> mm Hg at 25°C (low)
<b>HENRY'S LAW CONSTANT</b>	1.96 x 10 <sup>-4</sup> Pa m <sup>3</sup> mol <sup>-1</sup>
<b>OCTANOL/WATER PARTITION CO-EFFICIENT (log K<sub>ow</sub> at 25° C):</b>	434
<b>HYDROLYTIC STABILITY (DT<sub>50</sub>):</b>	Stable to hydrolysis
<b>AQUEOUS PHOTOSTABILITY (DT<sub>50</sub>):</b>	6.0 days
<b>SOIL PHOTOLYSIS (DT<sub>50</sub>):</b>	Negligible
<b>DISSOCIATION CONSTANT (pKa):</b>	9.78
<b>SOIL ADSORPTION (Kd) (Global):</b>	0.81-6.63 L/kg (average 3.30 L/kg)



<b>SOIL ADSORPTION CONSTANT (<math>K_{oc}</math>) (Global):</b>	190 - 570 mL/g (average 354 mL/g)																		
<b>SOIL HALF-LIFE (Field <math>DT_{50}</math>) (Global):</b>	34-309 days (average 121 days)																		
<b>SOLUBILITY (g/L) at 25°C:</b>	<table border="1"> <thead> <tr> <th>Solvent</th> <th>Solubility (g/L)</th> </tr> </thead> <tbody> <tr> <td>Water</td> <td>0.001</td> </tr> <tr> <td>Acetone</td> <td>50</td> </tr> <tr> <td>Acetonitrile</td> <td>30</td> </tr> <tr> <td>Dicloromethane</td> <td>50</td> </tr> <tr> <td>Ethyl acetate</td> <td>50</td> </tr> <tr> <td>n-hexane</td> <td>0.07</td> </tr> <tr> <td>methanol</td> <td>50</td> </tr> <tr> <td>toluene</td> <td>4.0</td> </tr> </tbody> </table>	Solvent	Solubility (g/L)	Water	0.001	Acetone	50	Acetonitrile	30	Dicloromethane	50	Ethyl acetate	50	n-hexane	0.07	methanol	50	toluene	4.0
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<p>The extremely low vapor pressure of isoxaben together with a low Henry's law constant indicate that it will not dissipate by volatilization.</p>																			

The technical information in this bulletin is not an offer for sale.

## Disclaimer

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**Isoxaben has not yet received federal registration for use in bearing tree nut orchards and vineyards; registration is pending.**