

# PALADIN<sup>®</sup>

SOIL FUMIGANT

Field hygiene is important for a healthy start to seedlings, transplants and overall plant health for crop production. The options for preplant soil treatments are limited, and growers are still looking for the next generation of effective methyl bromide alternatives.

United Phosphorus, Inc. (UPI) is now introducing an effective methyl bromide alternative: new Paladin<sup>®</sup> soil fumigant.



# What Is Paladin® Soil Fumigant?

Paladin® is a novel preplant soil fumigant that provides control or suppression of soil-borne diseases, weeds and nematodes. University and commercial trials have confirmed that Paladin® is effective for control of soil-borne pests in tomatoes, peppers, eggplants, cucumbers, squash, melons, blueberries, strawberries, field-grown ornamentals and forestry nursery crops. Paladin® is a Restricted Use Pesticide. The product label contains a U.S. Environmental Protection Agency (EPA) signal word of "WARNING."



## WHAT IS DMDS?

The active ingredient in Paladin® is dimethyl disulfide (DMDS). DMDS is everywhere in the environment and is produced biologically in plants (*Allium* and *Brassica* species), animals (milk, urine, by-products) and processed foods (salmon, bread, coffee). DMDS is an important part of the atmospheric sulfur cycle.

## APPLICATION PROGRAMS

**One-Pass Paladin® Program for Nematodes, Soil-borne Diseases and Weeds.** University- and EPA-approved Experimental Use Permit (EUP) field trials have shown that a Paladin® program that consists of Paladin® tank-mixed with chloropicrin (PIC) and a preplant non-incorporated bed surface application of a small-seeded weed herbicide offers excellent control of nematodes, soil-borne diseases and weeds. Essentially the same equipment previously used for methyl bromide applications can be used for Paladin®, so the equipment transition for growers to use Paladin® will be minimal.

**Shank Application Programs Using Paladin® Soil Fumigant.** A shank application Paladin® program consists of a tank mixture of 79 percent Paladin® and 21 percent chloropicrin (79:21 wt/wt). Application rates will typically be 50-60 gallons per acre (GPA). Use the higher rate for moderate to heavy disease or weed pressure. This program improves the effectiveness for soil-borne disease and weed control. UPI also recommends that Paladin® be followed by a preplant, non-incorporated bed surface application of a herbicide, such as Devrinol®, just prior to laying the plastic mulch, to increase the control of small-seeded broadleaves and grasses. See the Devrinol® label for approved crops and rates. Paladin® can be applied via broadcast or raised-bed applications.

### Paladin® + Chloropicrin (79:21) Tank-Mix Application Rates Per Acre

Paladin® + PIC (79:21)			Paladin®			Chloropicrin	
Gallons	Lbs	=	Gallons	Lbs	+	Gallons	Lbs
60	573	=	51.3	454	+	8.7	119.8
55	526	=	47.0	416	+	8.0	109.8
50	478	=	42.8	378	+	7.2	99.8
45	430	=	38.5	340	+	6.5	89.8

**Drip Application Programs Using Paladin® EC Soil Fumigant.** A Paladin® program is also available in an emulsifiable concentrate (EC) formulation for drip irrigation application. The Paladin® EC program consists of a tank mixture of 79 percent Paladin® EC and 21 percent chloropicrin (79:21 wt/wt). Application rates will typically be 55-63 GPA. Use the higher rate for moderate to heavy disease or weed pressure. UPI also recommends applying a preplant, non-incorporated bed surface application of an appropriate herbicide, such as Devrinol®, just prior to laying the plastic mulch, to increase the control of small-seeded broadleaves and grasses. See the Devrinol® label for approved crops and rates.

### Paladin® EC + Chloropicrin (79:21) Tank Mix Acre-Inch PPM x Application Rate

Acre inches	Paladin® EC + PIC		=	PPM DMDS	+	PPM PIC
	Gallons	PPM				
1.25	62.5	2,207	=	1,583	+	440
1.25	60.0	2,023	=	1,520	+	423
1.00	62.5	2,634	=	1,979	+	551
1.00	60.0	2,529	=	1,899	+	528
1.00	57.5	2,423	=	1,820	+	506
1.00	55.0	2,318	=	1,741	+	484
0.75	62.5	3,512	=	2,638	+	734
0.75	60.0	3,371	=	2,533	+	705
0.75	57.5	3,231	=	2,427	+	675
0.75	55.0	3,090	=	2,322	+	646

The concentration of Paladin® EC must be a minimum of 1,500 ppm and a maximum of 2,700 ppm in the drip tapes.



**Mulches Approved for Use.** One of the following labeled-approved mulches is required for all Paladin® and Paladin® EC applications:

- Olefinas® Embossed VIF
- Klerks VIF
- Pliant Blockade® (1.25 mL) black or white
- XL Blockade® (0.00125)
- Pliant Metalized black VIF
- Canslit® Metalized (1.25 mL) high-barrier black or white
- FilmTec VIF (1.25 mL)
- Ginegar VIF Embossed
- Cadillac VIF
- Guardian VIF (1.2 mL)
- Bromostop® (1.38 mL)
- Mid-South Extrusion VIF

See the Paladin® or Paladin® EC label for a complete list of approved mulches.

**Application Depth.** For shank applications: tarp-bedded and tarp-broadcast applications, using the injection point must be a minimum of 8 inches from the nearest final soil/air interface. The application depth in preformed beds must not be below the bed furrow.

**Subsurface Irrigation.** Raising the water table into the injection zone prior to planting will reduce Paladin® efficacy and increase plant-back interval.

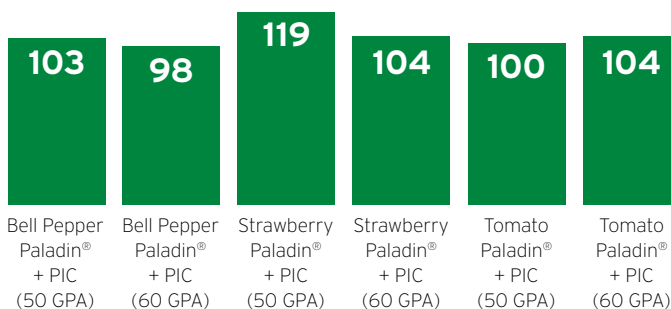
**Plant-Back Intervals.** The length of time may vary for Paladin® to dissipate from the soil before transplanting and seeding are safe. Circumstances that do not favor the dissipation of Paladin® and can possibly lengthen the plant-back interval include heavy soils, low soil temperatures and high soil moisture.

## FIELD TESTED

**Supported by University Trials and EPA-Approved Experimental Use Permits (EUP).** Since 2004, extensive R&D studies on over 250 field trials in 15 countries have been carried out to assess and confirm Paladin® soil fumigant efficacy and crop safety. From 2007-2010, extensive research was conducted on the use of Paladin® through Experimental Use Permits. More than 20 cooperators in three states were involved in these studies. There were 39 different EUP sites with field trial results collected on 117 treated acres.

### Paladin® EUP Trials 2007–2010 Yield Percent of Methyl Bromide/Standard

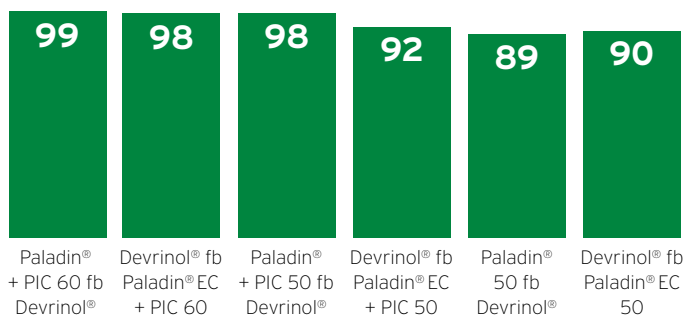
50 GPA = Avg. of 46–55 GPA, 60 GPA = Avg. of 56–65 GPA



**Broad-Spectrum Weed Control.** While Paladin® + chloropicrin offers excellent control of purple and yellow nutsedge, the addition of a preplant, non-incorporated bed surface application of Devrinol® herbicide, applied just prior to laying the plastic mulch, will provide increased control of small-seeded broadleaves and grasses. Devrinol® should be applied to the finished bed surface just prior to laying the plastic mulch in peppers, tomatoes, eggplants and strawberries. Please see the Devrinol® label for a complete list of labeled crops and use recommendations.

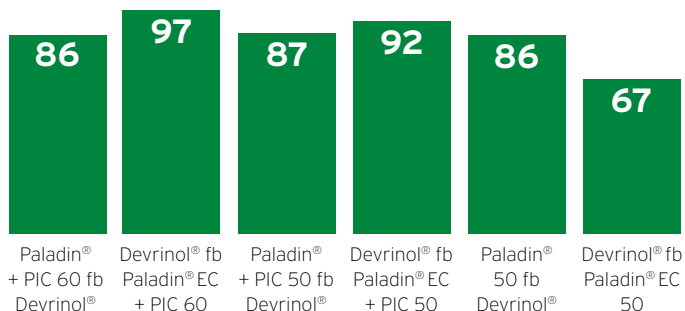
### Paladin® R & D 2008–2010 Trial Summary – Broadleaf Weed Control (with Devrinol®) Average Percent Control

Paladin® + PIC = Paladin® + Chloropicrin (79:21) Tank Mix



### Paladin® R & D 2008–2010 Trial Summary – Grass Control (with Devrinol®) Average Percent Control

Paladin® + PIC = Paladin® + Chloropicrin (79:21) Tank Mix





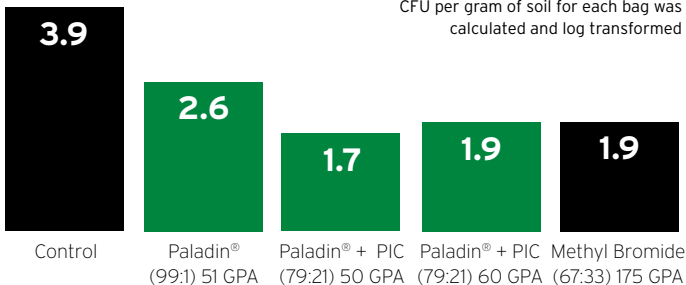
University nutsedge trial 52 days after treatment: Paladin® + PIC (79:21) left, UTC right.

**Broad-Spectrum Soil-borne Disease Control.** Paladin® soil fumigant used alone is effective on many soil-borne diseases. The addition of chloropicrin expands the spectrum of control.

**Buried-Bag Assays – Paladin® Trials**  
**Average Colony-Forming Unit (CFU)/g Soil**

Dr. Gary E. Vallad, University of Florida, IFAS, Gulf Coast REC  
 Average of three trials Spring '08 and '09, Fall '08  
*F. oxysporum* f.sp. *lycopersici* (causal agent of Fusarium wilt of tomato)

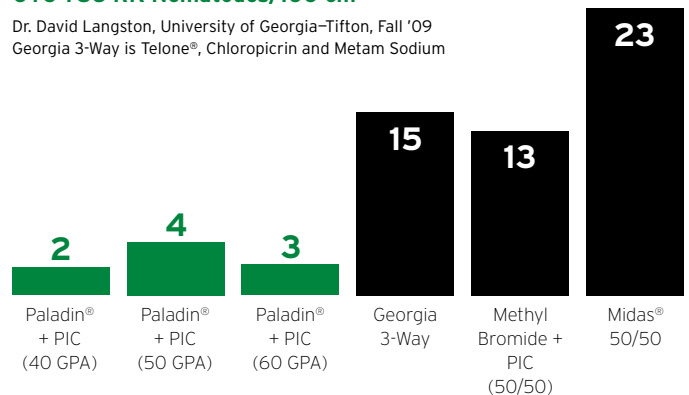
CFU per gram of soil for each bag was calculated and log transformed



**Nematode Control.** Paladin® soil fumigant offers excellent nematode control.

**University of Georgia 2009 Fall Root-Knot Nematode Trial**  
**Nematode Counts/100 cm<sup>3</sup>**  
**UTC 786 RK Nematodes/100 cm<sup>3</sup>**

Dr. David Langston, University of Georgia-Tifton, Fall '09  
 Georgia 3-Way is Telone®, Chloropicrin and Metam Sodium





## APPLICATION EQUIPMENT/PPE

**The U.S. EPA requires that for all Paladin® soil fumigant treatments, the applicator supervising the application must be registered, trained and state certified/licensed.** Contact your local Paladin® distributor for **Paladin® registrant applicator** training details.

### Site-Specific Fumigation Management Plan (FMP)

- Prior to the start of fumigation, the certified applicator supervising the application must verify that a site-specific FMP exists for each application block.
- The FMP must be prepared by the certified applicator, the site owner/operator, registrant or other party. The certified applicator must verify in writing (sign and date) that the site-specific FMP(s) reflects current site conditions before the start of fumigation.

### Paladin® Soil Fumigant Good Agricultural Practices (GAPs) Calibration, Setup, Repair and Maintenance for Paladin® Application Rigs.

Brass, carbon steel or stainless steel fittings must be used throughout. High-density polyethylene tubing, fluoropolymer (PFA, PTFE or PVDF) tubing or fluoropolymer-lined steel braided tubing must be used for all low-pressure lines, drain

lines, and compressed-gas or air pressure lines. All other tubing must be fluoropolymer (PFA, PTFE or PVDF)-lined and steel braided.

### Paladin® EC Soil Fumigant Good Agricultural Practices (GAPs)

- From the Paladin® EC cylinder to the injection point into the irrigation water (where components are exposed to undiluted Paladin® EC), use components having wetted surfaces made of stainless steel, steel, fluoropolymer (PFA, PTFE and PVDF), EPDM and/or Viton®. Paladin® will corrode brass and other copper alloys over time. Do not use PVC, galvanized steel, nylon or aluminum.
- From the Paladin® EC injection point, after mixing with irrigation water, the drip irrigation system may include components made of rigid PVC, stainless steel, steel, polyethylene, nylon, fluoropolymer, EPDM and/or Viton®. The drip irrigation system downstream of the injection point must not be exposed to Paladin® EC at concentrations exceeding 2,700 ppm (wt/wt).
- Do not allow Paladin® EC to sit in polyethylene tubing for extended periods. Polyethylene tubing may swell or soften over time.

**Volume Flow Meter and Tubing Requirements.** Monitoring the flow meter to ensure the proper amount of Paladin® + chloropicrin is injected is important for effective control and crop safety. Paladin® labeled application volumes are greater than current methyl bromide labeled volumes. Paladin® applications could require a larger-volume flow meter, orifice or tubing to meet required flow rates with existing application equipment.

**How to calibrate equipment for application**

inches per bed	÷	chisels per bed	=	row width inches applied per chisel
row width inches applied per chisel	÷	12 (inches per foot)	=	row width feet applied per chisel
row width feet applied per chisel	x	mph x 88 <sup>1</sup>	=	square feet treated per minute per chisel
square feet treated per minute per chisel	÷	43,560 (square feet per acre)	=	square acres treated per minute per chisel
square acres treated per minute per chisel	x	gallons per acre	=	gallons applied per minute per chisel <sup>2</sup>
gallons applied per minute per chisel	x	chisels per bed	=	gallons applied per minute per bed
gallons applied per minute per bed	x	beds per tractor	=	gallons applied per minute per tractor
gallons applied per minute per tractor			=	flow meter capacity

1) mph is tractor speed and 88 converts mph to feet per minute.  
 2) Gallons applied per minute per chisel equals orifice or tubing capacity from flow divider to chisel.



**Flow Meter and Tubing Requirements – Volumes**

Gallons per minute by bed-top width, application speed and rate

Bed width (inches)	60 GPA			50 GPA		
	6 mph	5 mph	4 mph	6 mph	5 mph	4 mph
36	2.2	1.8	1.5	1.8	1.5	1.2
34	2.1	1.7	1.4	1.7	1.4	1.1
32	1.9	1.6	1.3	1.6	1.4	1.1
30	1.8	1.5	1.2	1.5	1.3	1.0
28	1.7	1.4	1.1	1.4	1.2	0.9
26	1.6	1.3	1.1	1.3	1.1	0.9
24	1.5	1.2	1.0	1.2	1.0	0.8

Contact your Paladin® distributor for questions about flow meter and tubing requirements.

**Personal Protective Equipment (PPE).** If any handler detects the garlic-like odor of this product, then a half-face or full-face air-purifying respirator with a pesticide-approved organic vapor cartridge filter or equivalent (NIOSH-approved number prefix TC-23C) must be worn.

Handlers wearing respirators after one hour and at hourly intervals thereafter can remove their air-purifying respirators momentarily to determine if the garlic-like odor is still detectable. If detectable, the respirator must be put back on.

All handlers (including applicators) performing any tasks with Paladin® liquid contact potential must wear:

- Loose-fitting or well-ventilated long-sleeved shirt and long pants
- Chemical-resistant gloves
- Chemical-resistant footwear
- Socks
- Full-face shield or safety glasses with brow, temple and side protection. DO NOT wear goggles.

All handlers (including applicators) performing any tasks without DMS liquid contact potential must wear a loose-fitting or well-ventilated long-sleeved shirt, long pants, shoes and socks.

See label for complete PPE requirements.

## APPLICATION CONDITIONS

### Weather Conditions

- Prior to fumigation, the weather forecast for the day of the application and the 48-hour period following the fumigation must be checked to determine if unfavorable weather conditions exist (see "Identifying Unfavorable Weather Conditions," below) or are predicted and whether fumigation should begin.
- Wind speed at the application site must be a minimum of 2 mph at the start of the application or forecasted to reach at least 5 mph during the application.
- Do not apply if a shallow, compressed (low-level) temperature inversion is forecasted to persist for more than 18 consecutive hours for the 48-hour period after the start of the application, or if there is an air stagnation advisory issued by the National Weather Service in effect for the area in which the fumigation is planned.

**Identifying Unfavorable Weather Conditions.** Unfavorable weather conditions block upward movement of air, which results in trapping fumigant vapors near the ground. The resulting air mass can move off-site in unpredictable directions. These conditions typically exist prior to sunset and continue past sunrise and persist as late as

noon. Unfavorable conditions are common on nights with limited cloud cover and light to no wind. Their presence can be indicated by ground fog or smog as well as smoke from a ground source that flattens out below a ceiling layer and moves laterally in a concentrated cloud.

**Soil Temperature for Paladin® Soil Fumigant.** The soil temperature at the depth of injection must not be less than 45°F or exceed 90°F at the beginning of the application.

**Soil Moisture for Paladin® Soil Fumigant.** The soil moisture must be at least 75 percent of field capacity from 2 inches below the soil surface to a depth of 9 inches below the surface.

**Soil Moisture for Paladin® EC Soil Fumigant.** Prior to a Paladin® EC application, a pre-chemigation irrigation should be conducted to ensure soil moisture is uniformly at, or near, field capacity throughout the treatment area. This will improve the distribution of Paladin® EC through the soil profile of the bed, to stimulate activity and growth of soil-borne pathogens and nematodes and to initiate germination of weed seed.



## APPLICATION INFORMATION

**Buffer Zone Requirements.** Buffer zone perimeters must be clearly posted or otherwise controlled to restrict entry. Buffer zones remain in effect for 48 hours following the completion of a fumigation treatment.

### Paladin® Buffer Zone's Raised-Bed Applications Paladin® + Chloropicrin (79:21) Tank Mix

Bed width % of row	Paladin® + PIC (79:21) GPA	Acres/Buffer Zone Feet								
		1	5	10	15	20	25	30	35	40
62.5	60	25	25	80	110	140	165	190	215	240
62.5	55	25	25	75	105	135	160	185	210	230
62.5	50	25	25	60	90	115	140	160	185	205
62.5	45	25	25	45	75	105	125	145	165	185
50.0	60	25	25	50	80	110	135	155	175	195
50.0	55	25	25	40	65	95	115	135	155	175
50.0	50	25	25	30	55	80	100	120	140	155
50.0	45	25	25	25	35	60	80	95	115	130

### Posting Notification Requirements

- Notify workers of the application by warning them verbally and by posting Fumigant Treated Area signs. The Fumigant Treated Area signs must bear the skull-and-crossbones symbol and state:

- (1) WARNING/AVISO
- (2) Areas under fumigation, DO NOT ENTER/ NO ENTRE
- (3) Dimethyl Disulfide Fumigant in Use
- (4) Date and time of fumigation
- (5) Date and time entry-restricted period is over
- (6) Paladin® and (fill in co-application)
- (7) Name, address and telephone number of the certified applicator in charge of the fumigation

- Post the Fumigant Treated Area signs instead of the Worker Protection Standards (WPS) signs for this application, but follow all WPS requirements pertaining to location, legibility, size and timing of

posting and removal.

- Post the Fumigant Treated Area signs at all entrances to the application block (i.e., the field or portion of a field treated with a fumigant in any 24-hour period).

**Entry-Restricted Period.** Entry (including early entry that would otherwise be permitted under the WPS) by any person, other than a correctly trained and PPE-equipped handler who is performing a handling task listed on this labeling, is PROHIBITED from the start of the application until:

- Five days after application is complete if tarps are not perforated and not removed for at least 21 days after application is complete.
- Forty-eight hours after tarp perforation is complete if tarps are perforated less than 21 days after the application is complete and tarps will not be removed prior to planting.
- Tarps have been left intact for a minimum of 21 days after the application has been completed; then, planting or transplanting may take place while the tarps are being perforated.
- Additional requirements on label are met.

### Early Signs and Symptoms of Exposure

- DMDS, the active ingredient in Paladin® soil fumigant, has a strong, objectionable odor that can be detected at concentrations significantly below the levels that can potentially cause harm. The odor is garlic-like and may be confused with the odor of a natural gas or propane leak. The odor of DMDS may cause nausea, headache, drowsiness or dizziness.



- At concentrations significantly greater than its odor threshold, DMDS may cause nasal irritation. Exposure to liquid DMDS may also cause skin irritation.

**Odor Mitigation.** A number of practices can be followed to mitigate the odor, as well as to minimize worker and bystander exposure. Some of these preventive measures include the following:

- Soil must be properly prepared, and at the surface generally free of large clods. The area to be fumigated must be tilled to a depth of at least 5 to 8 inches.
- Residue from a previous crop must be worked into the soil to allow for decomposition prior to fumigation. Little or no crop residue should be present on the soil surface.
- Ensure soil moisture is greater than 75 percent field capacity and preferably closer to 100 percent depending on soil type.
- Ensure beds are firm.
- Ensure shanks are in the soil prior to injection at start of row.
- Cut off injection prior to stopping at the end of the row.
- Purge injection lines prior to raising shanks from soil.

- Use only approved tarps outlined in the Paladin® label.
- Ensure tarp is securely tucked.
- Do not disturb treated soil after application.
- Squaring of end rows, shoveling water furrows and cutting lanes should be accomplished in untreated soil.
- Sealing sprinkler riser holes.
- Cooling of beds with irrigation two to three hours before dark when bed temps are >90°F.
- Fields should naturally drain away from odor-sensitive areas.
- Contact your local first responders (police, fire, EMT) and propane companies prior to application to advise you are applying Paladin® soil fumigant and the odor is similar to garlic or propane odorant. (See Community Outreach Handout.)
- Do not apply within one-quarter mile of nursing homes, hospitals or prisons; or licensed schools, licensed day care facilities or licensed assisted-living facilities (licensed by state or local governments) that will be occupied during the buffer-zone period.
- Applications are limited to no more than 40 contiguous acres a day.







**Paladin® Agronomic Inquiries:  
Contact your local UPI sales  
representative, call 1-800-438-6071  
or visit [www.upi-usa.com](http://www.upi-usa.com).**

In case of personal or potential exposure,  
contact your local emergency responders or the  
Paladin® Hotline: (800) 286-4110

Transportation/Storage: Spills, Leaks, Fire or Accident:  
Chemtrec (800) 424-9300

MEDICAL: (Rocky Mountain Poison Control Center)  
(866) 767-5089

For more information, see <http://www.Paladin.com>.

