

New Fumigants for Strawberry Production in California

Dominus[®], Paladin[®], Trifecta[®], and EDN

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UCCE**



Dominus[®]

Allyl isothiocyanate (AITC)

- **EPA Registration was granted Sept 2013 (Isagro USA)**
- **Synthetically produced biopesticide that is found in brassica**
- **Pre-plant Application rate: 200 – 350 lbs/a**
- **Small buffer zones, no FMP**

Selected properties of Dominus

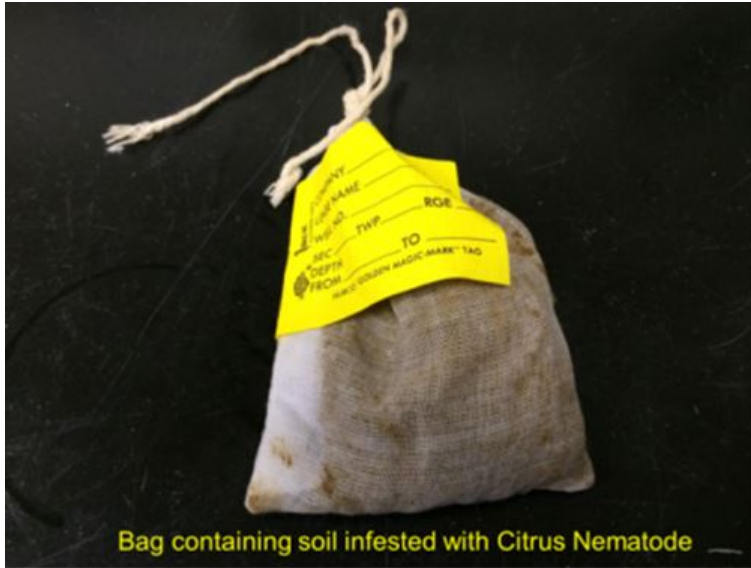
CAS #	57-06-7
Boiling point	151°C
Vapor pressure	3.5 – 4 mm Hg
Vapor density (water = 1.0)	3.4
Density	1.0126 g/cm ³ @ 20°C
Solubility in water	Slight, 2 g/L water @ 25°C
Solubility in alcohol	Very soluble (1:8) in 80% ethanol
Henry's Law Constant	0.0002752 atm-m ³ /mole
Molecular formula	C ₄ H ₅ NS
Molecular weight	99.1542 g/mol
Soil half-life, DT50)	Aerobic DT50 of less than 3 days

Paladin

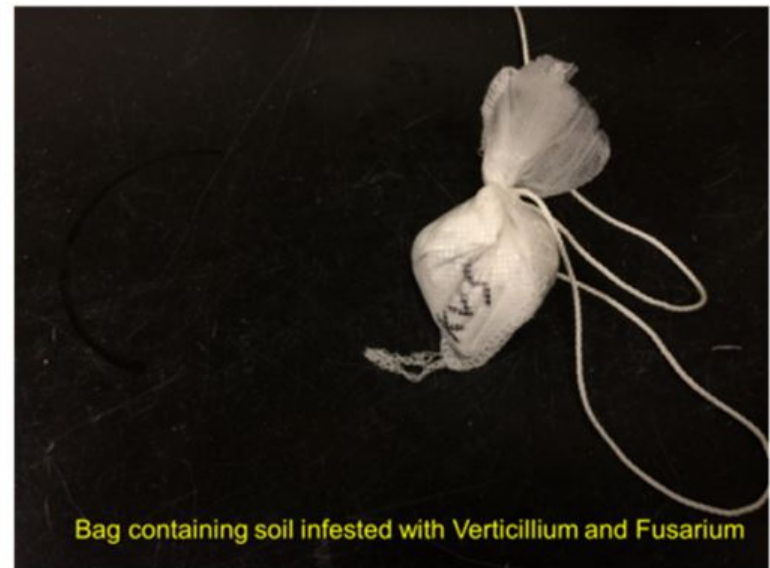
Dimethyl disulfide (DMDS)

- **EPA Registration was granted in 2010 (Arkema)**
Applied only under TIF
- **Used as a flavoring for an onion or garlic taste in processed cheese and meat (0.02-10 ppm)**
- **Efficacy (Rates: 400 – 600 lbs/a)**

Laboratory Dose-Response Studies



Bag containing soil infested with Citrus Nematode



Bag containing soil infested with Verticillium and Fusarium



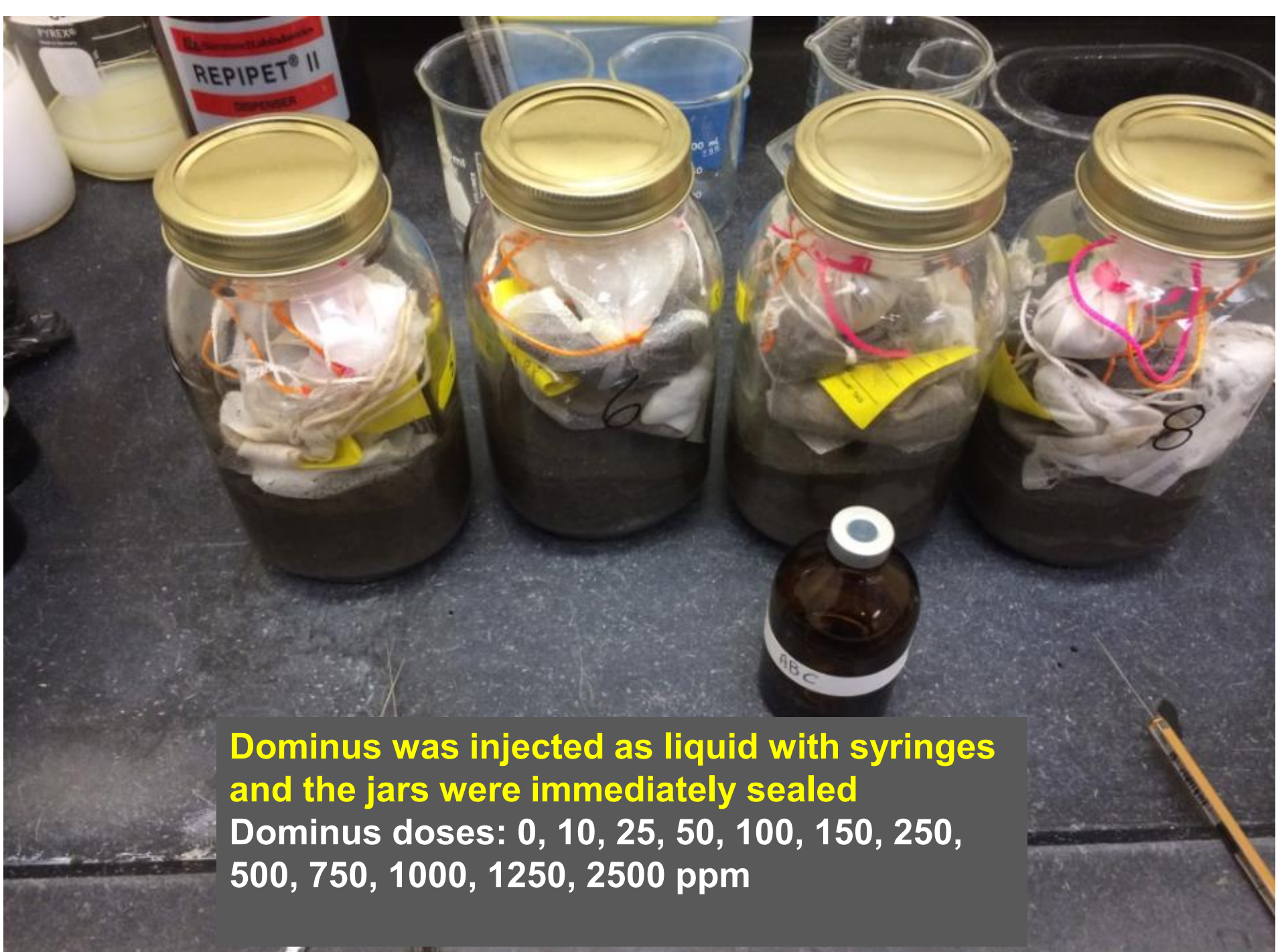
Bag containing soil infested with Pythium



Bag containing soil infested with Phytophthora

Laboratory Dose-Response Studies





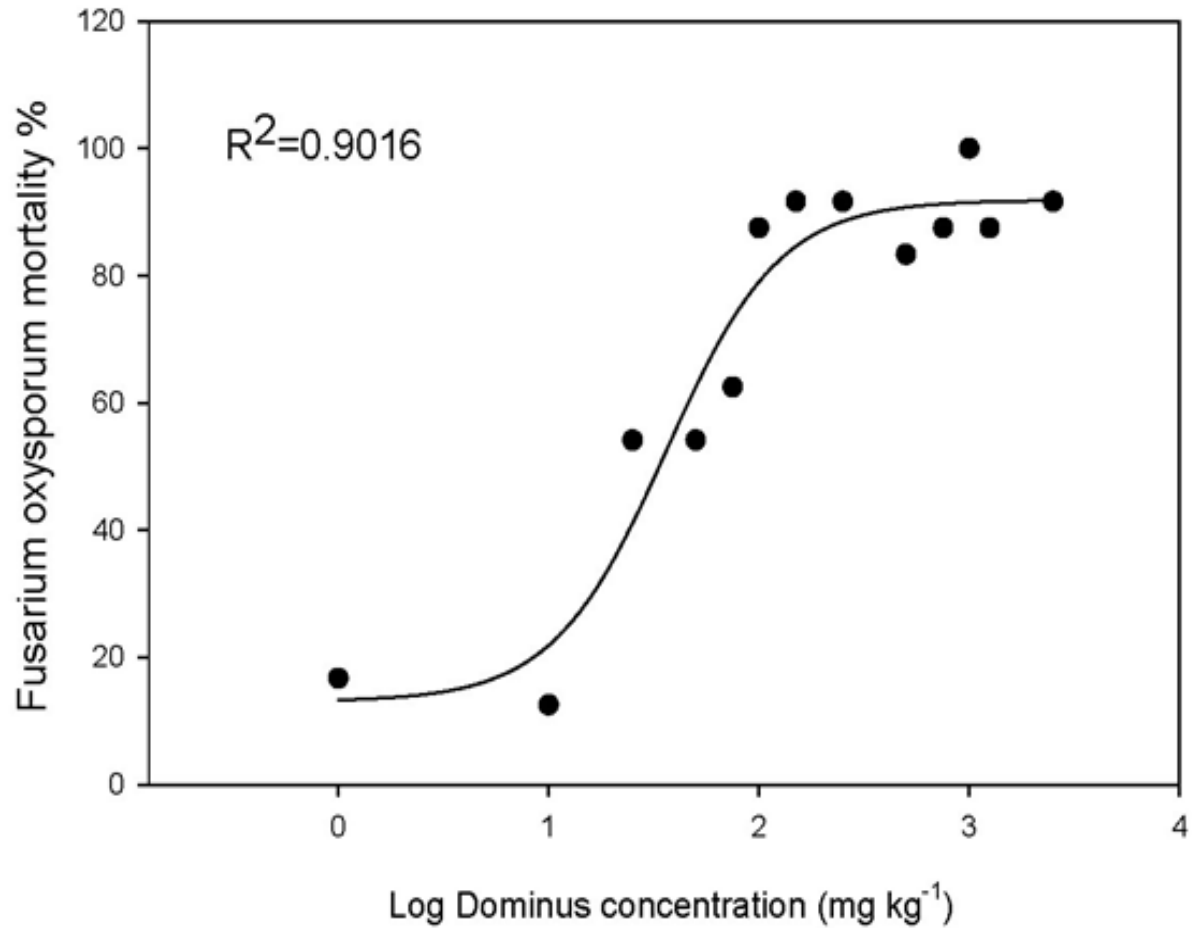
**Dominus was injected as liquid with syringes
and the jars were immediately sealed**

**Dominus doses: 0, 10, 25, 50, 100, 150, 250,
500, 750, 1000, 1250, 2500 ppm**

The fumigated jars were placed in incubators at 20°C for 24 hours



Dose-response curve



Dose (lbs/ac) required to control 90% of pathogen population (LD₉₀)

Fumigant	<i>Fusarium oxysporum</i>	<i>Verticillium dahliae</i>
Paladin (79:21)	315	406
Dominus (96%)	232	159
PicClor 60 (60:40)	146	230

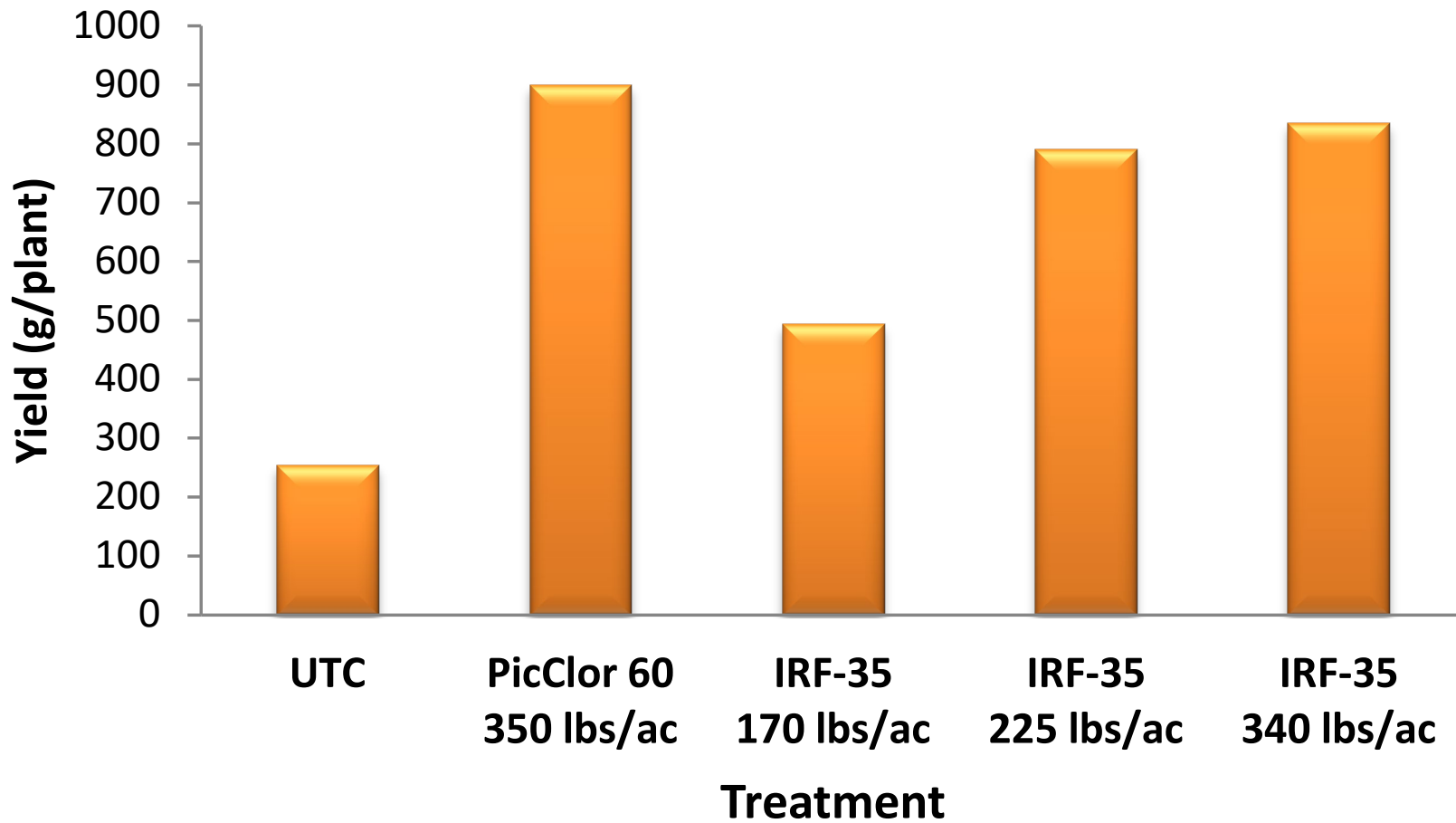
1 mg/kg = 2 lbs/ac for a soil depth of 6.7 inches

Field Research

Watsonville: Non-fumigated field for past 2 years.
Fusarium pressure is severe.



Early Season Yield from Clear Plastic* at Watsonville, CA - 2013



* Standard PE Film

Watsonville, 2014



**240 lbs Dominus
+
120 lbs chloropicrin**

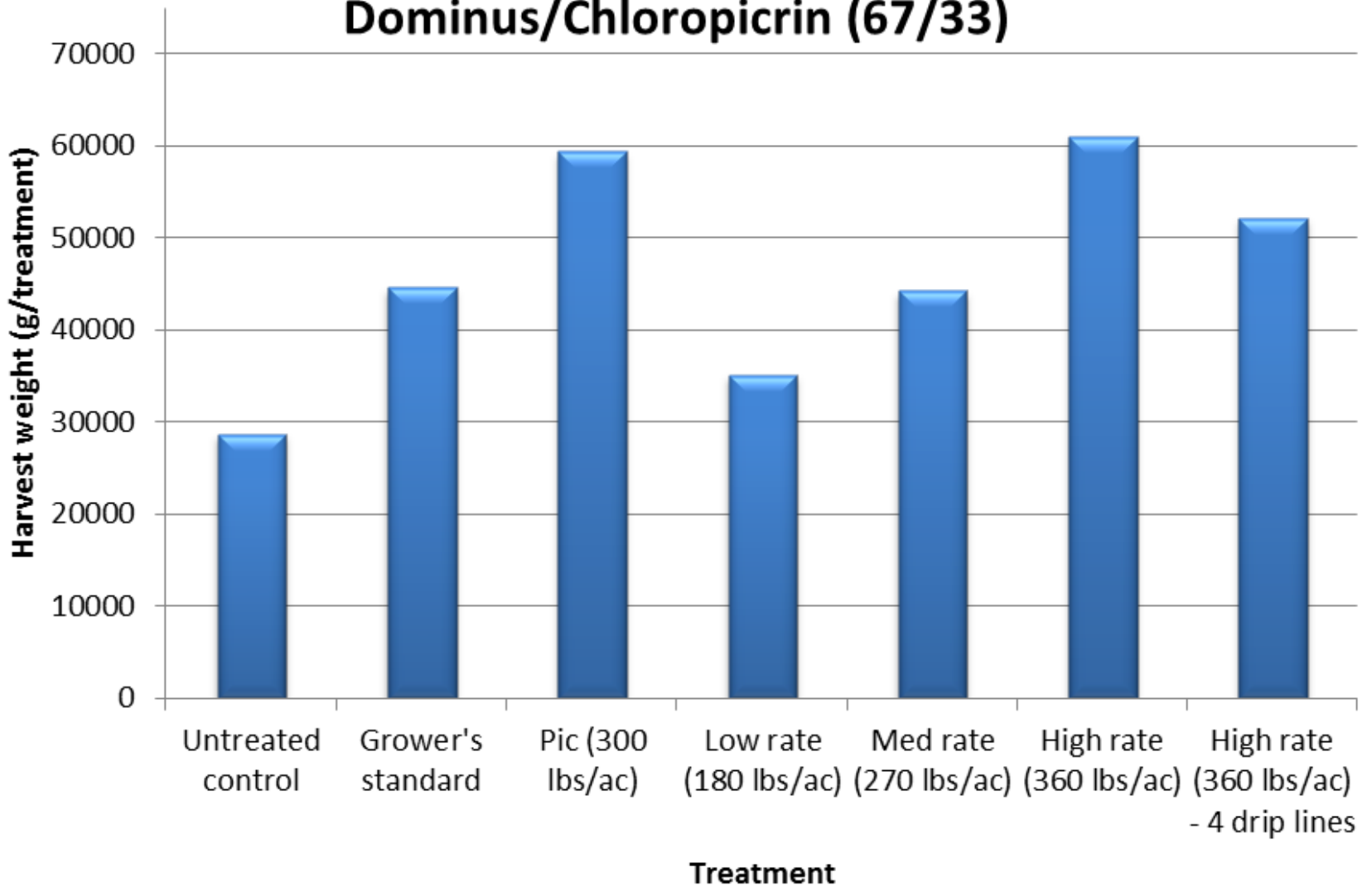
**160 lbs Dominus
+
80 lbs chloropicrin**



**Untreated
control**

Strawberry Yield, Watsonville, 2014

Dominus/Chloropicrin (67/33)



DRIP FUMIGATION

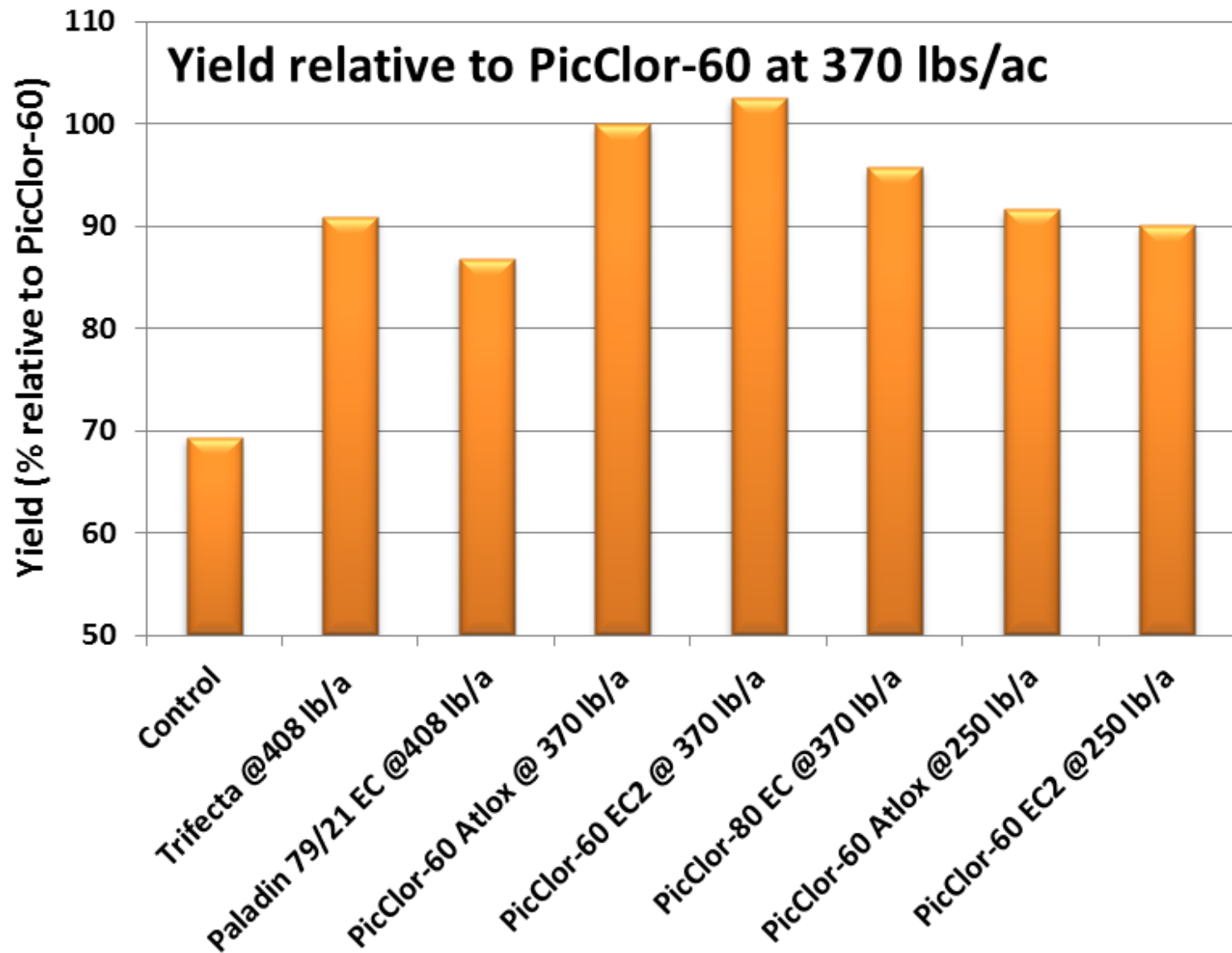
Dominus Treatments, 2014-2015

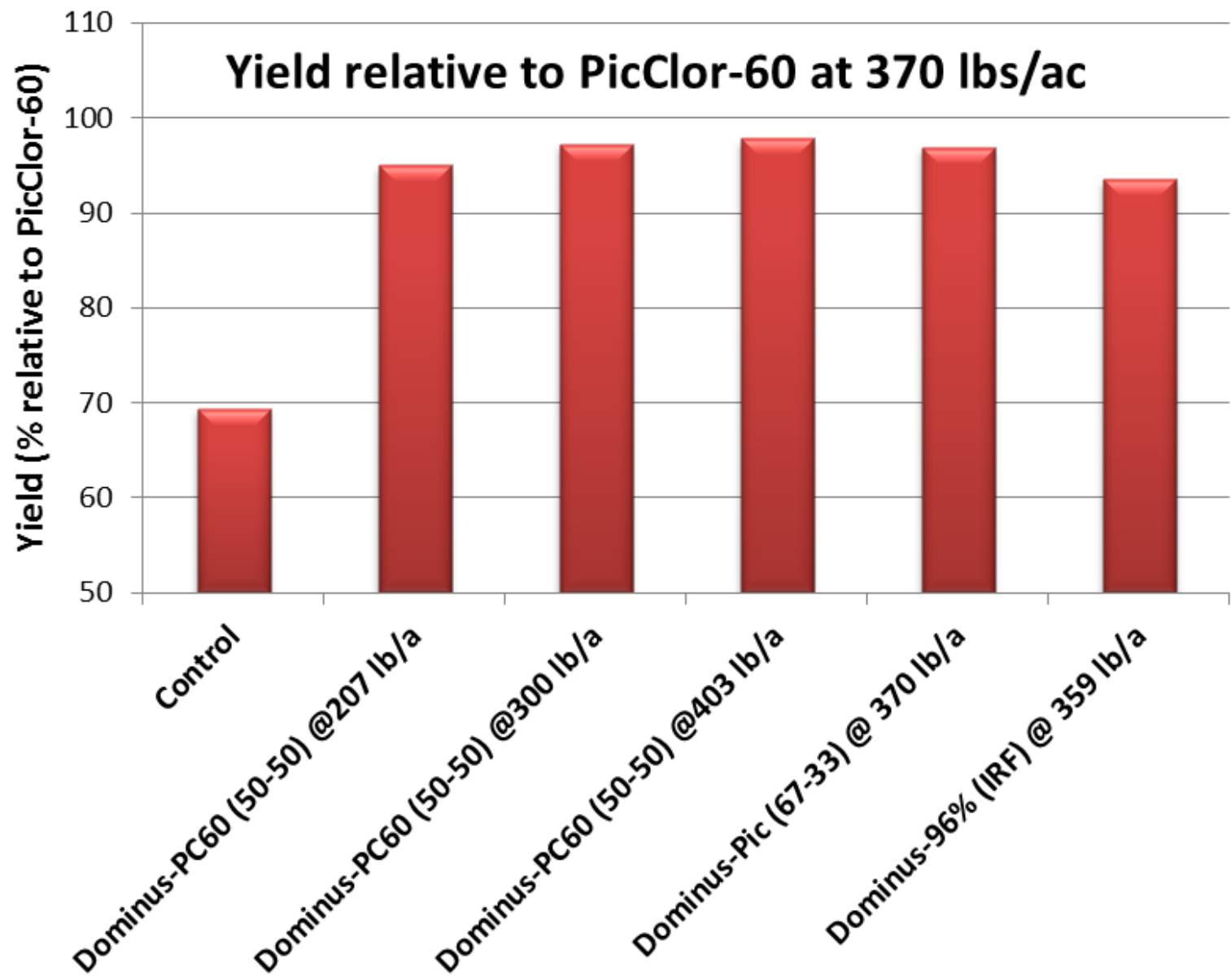
Treatment	Rate (lbs/ac)
Dominus/PicClor-60 (50/50)	207
Dominus/PicClor-60 (50/50)	300
Dominus/PicClor-60 (50/50)	403
Dominus/Chloropicrin (67/33)	370
Dominus (96%)	359

Paladin and PicClor-80, 2014-2015

Treatment	Rate
PicClor-80 (80% chloropicrin)	370 gal/ac
Paladin 79:21	408 lbs/ac
Trifecta (DMDS/Pic/1,3-D)	408 lbs/ac

Rates are per treated acre. Broadcast equivalent = treated acre rate x 0.63





Summary

Dominus (IRF-135)

- ❖ **No phytotoxicity or plant injury was observed when planting 10 days after fumigation.**
- ❖ **Dominus alone or with Chloropicrin (50/50) produced strawberry yields >94% compared to the standard PicClor-60 EC at 370 lbs/ac.**

2016 research

- **to evaluate optimum amount of irrigation water for drip fumigation of a new emulsifiable concentrate formulation of Dominus for strawberry production in California.**
- **to evaluate the effect of an azeotrope on the mobility of Dominus in soil.**
- *The focus of this presentation is to evaluate the overall yields during the growing season of 2015-2016.*

Dominus Treatments, 2015-2016

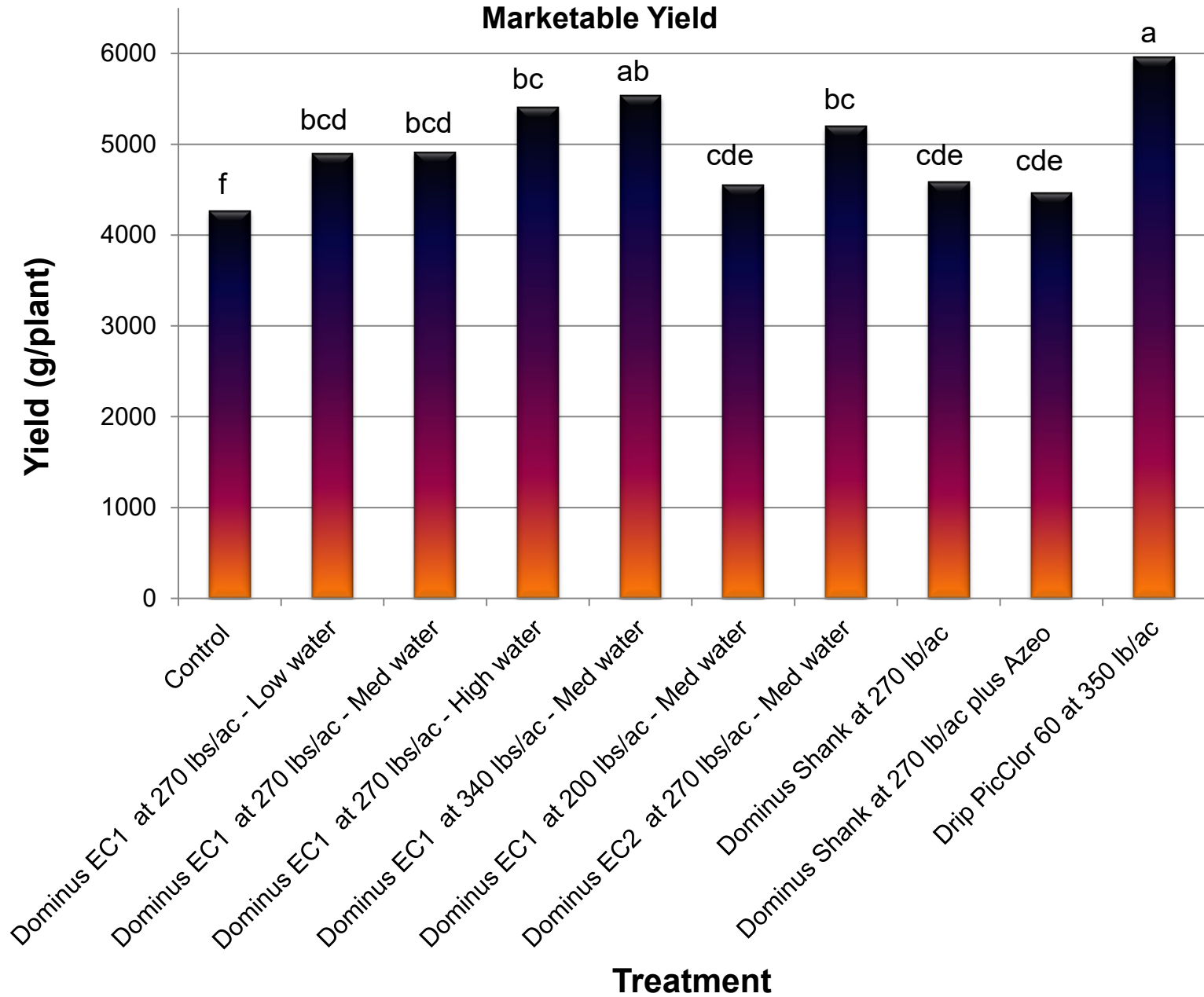
DOMINUS EC1- Low water (0.6")	270 lb/ac
DOMINUS EC1- Med water (1.0")	270 lb/ac
DOMINUS EC1- High water (1.4")	270 lb/ac
DOMINUS EC1- Med water (1.0")	340 lb/ac
DOMINUS EC1- Med water (1.0)	200 lb/ac
DOMINUS EC2 - Med water (1.0")	270 lb/ac
DOMINUS Shank	270 lb/ac
DOMINUS- Shank plus Azeotrope	270 lb/ac
Drip PicClor-60 EC	350 lb/ac

Shank injection: 2 shanks spaced 10 inches apart

AITC and a fluorocarbonyl azeotrope mixture was applied at a 50/50 ratio to soil (270 lbs/ac of AITC) using 2 shanks/bed at 8" deep.



Results



Summary

Dominus (IRF-135)

- ❖ **Strawberry yields increased with increasing the amount of water used to apply Dominus.**
- ❖ **Adding an Azeotrope to Dominus did not improve Dominus diffusion in the soil.**
- ❖ **A new emulsifier and other azeotropic combinations are being evaluated.**

FATE OF ETHANEDINITRILE (C₂N₂) FUMIGANT IN SOIL

→ EDN™ FUMIGAS manual for fumigation

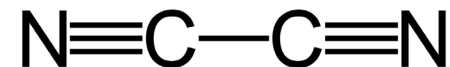


EDN™ FUMIGAS
fumigant.

Manual for fumigation.



Selected Properties of Ethanedinitrile



Product Brand Name:	EDN (ETHANEDINITRILE, C₂N₂)
USEPA Reg. No.:	62719-321
% Active Ingredient:	99.58%
Chemical Family:	DiCyanogen
Color, Odor.	Colorless gas, almond-like odor.
Molecular Formula:	C ₂ N ₂
Molecular Weight:	52
CAS No.:	460-19-5
Density:	Gas: 2.189 mg/cm ³ @ 20°C Liquid: 989 mg/cm ³ @ -40°C
Boiling Point:	-20°C
Vapor Pressure:	5.16 bar @ 21.1°C
Solubility in water @101.325kPa@20°C	450 cm ³ /100 cm ³ water

Properties of EDN

- It diffuses through soils quickly.
- Threshold Limit Value (TLV Human) = 10 ppm or 21 mg/m³.
- LC₅₀ (inhalation) 350 ppm/1 hour (rat).
- LDLo (subcutaneous) 13 mg/kg (rabbit).
- **It is effective in controlling soil-borne fungal pathogens, nematodes, and many weeds.**

PRELIMINARY INVESTIGATION OF ETHANEDINITRILE FOR CONTROL OF WEEDS AND NEMATODES IMPORTANT TO FLORIDA PRODUCTION SYSTEMS

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Gary L. Peterson

USDA ARS NAA, Foreign Disease-Weed Science Research Unit, Fort Detrick, MD
Colin Waterford
CSIRO, Entomology, Canberra, ACT 2601, Australia



Background

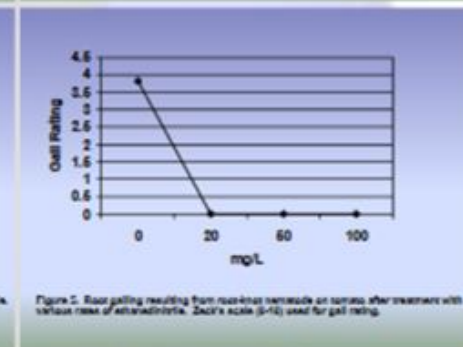
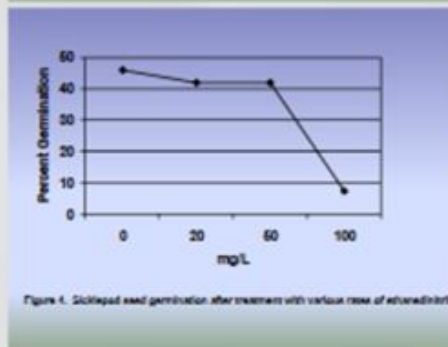
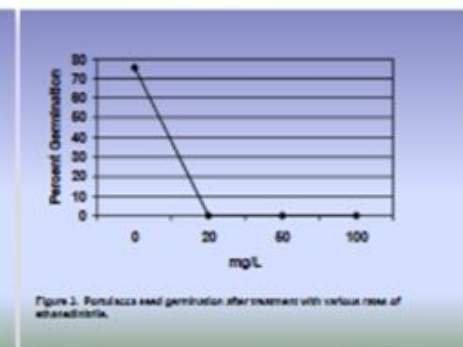
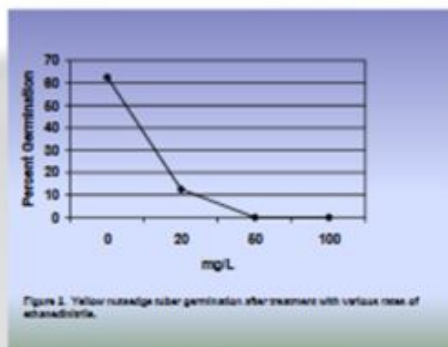
Previous experiments conducted in Australia with ethanedinitrile have demonstrated control of weeds and diseases of importance to the production of a variety of crops (Ren *et al.*, 2002). Pests included seed and soilborne fungi (Smith *et al.*, 2003) as well as plant-parasitic nematodes. Weed control in these trials was most effective when plots were tarped and was dependent upon species (Mattner *et al.*, 2003; Ren *et al.*, 2003).

Methods

- A preliminary *in vitro* experiment was conducted with seeds of several weed species of importance in vegetable and ornamental production systems in Florida, and with root-knot nematode (*Meloidogyne incognita*) infested soil.
- The prepared weed and nematode inoculum were placed in open desiccators of measured volume, allowed to equilibrate to the test relative humidity, sealed, and injected with a test amount of EDN through a gas septum port, having first withdrawn an equivalent volume of air (Figure 1).



Results



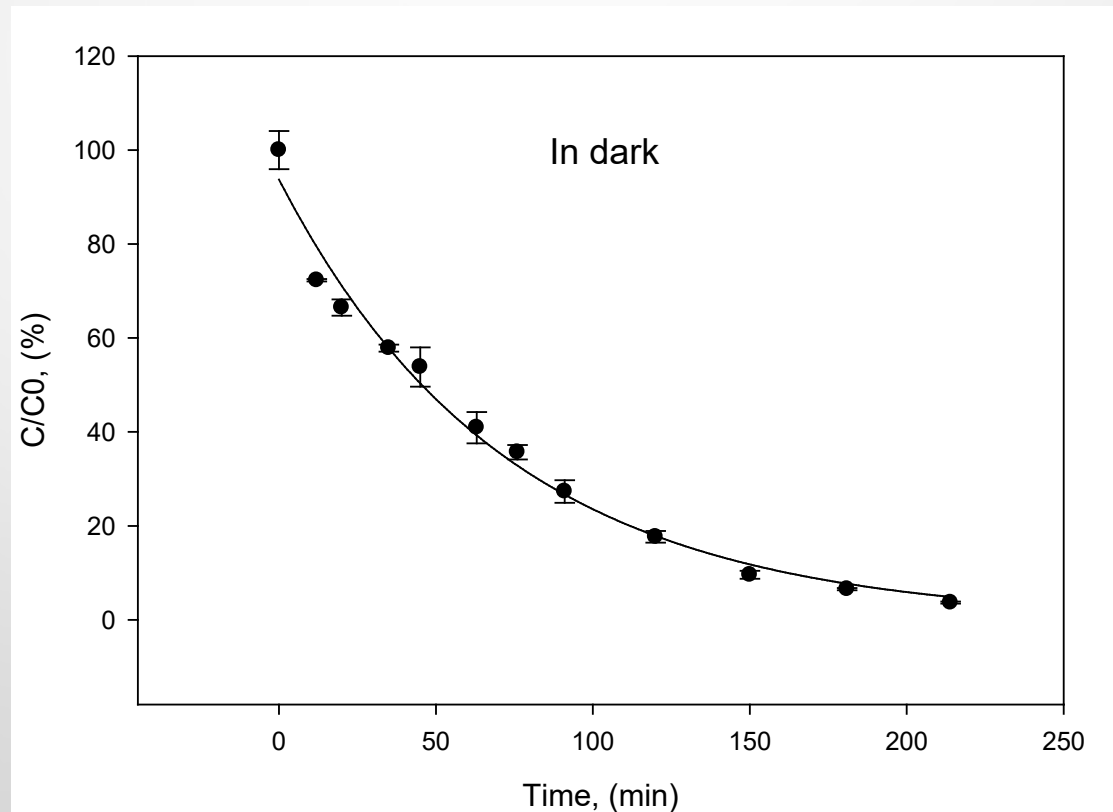
Research Objectives:

- 1. To evaluate the persistence (degradation) of EDN in different soil types.**
- 2. To measure the production and disappearance of EDN's main metabolites in different soil types.**

**EDN degrades very rapidly in air, soil, and water.
The half-life:**

- **in air: 100 days (light) to 150 days (dark).**
- **in soil and water: minutes to days, depending on the pH and temperature.**

**Example:
EDN hydrolysis in
pH 7.0 solution at
23°C.**



EDN degradation in water (hydrolysis) as a function of pH and temperature

pH/ Temp. (°C)	pH 4.0	pH 7.0	pH 9.0
10	80 * days	257 min	6.0 min
23	28# days	49 min	4.5 min
40	1.5 days	11 min	1.7 min

Summary

- Application rates might need to be adjusted based on soil pH and temperature.
- EDN metabolites are expected to degrade to non-toxic compound within days after fumigation.
- Possible degradation products:
 - $\text{NCCN} + 2\text{H}_2\text{O} \rightarrow \text{HCN} + \text{HOCN}$
 - $\text{HOCN} + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{CO}_2$
 - $\text{HCN} + \text{H}_2\text{O} \rightarrow \text{HC(O)NH}_2 + \text{H}_2\text{O} \rightarrow \text{HCO}_2^- + \text{NH}_4^+$
- HCN converts into thiocyanate (SCN) and eventually into $\text{SO}_4 + \text{NH}_3 + \text{CO}_2$ or forms precipitates with metals (eg., Fe)



Thank you very much

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