Evaluation of EDN Fumigas for use in Strawberry

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Summary

We evaluated EDN fumigas as a soil fumigant for use in strawberry. We conclude that it is safe on strawberry and an effective management tool for *Macrophmina*, purple nutsedge and broadleaf and grass weeds. EDN applications increase soil ammonia levels but not necessarily nitrate levels. Additional data is needed to verify activity on nematodes.

EDN Fumigas

EDN Fumigas (EDN) is a soil fumigant with the active ingredient ethanedinitrile. It is currently being evaluated for use in a wide variety of fruit and vegetable crops throughout the USA. EDN is of particular interest because it has a vapor pressure that is greater than methyl bromide and it has a low molecular weight. These physical attributes should result in extensive diffusion through the soil. In addition, EDN decomposes rapidly in soil, water and air with no anticipated negative impacts on the ozone layer. Preliminary research has found that EDN can effectively control a range of pests and pathogens including yellow nutsedge, common purslane, sickle-pod, and root-knot nematode.

Methods

Experimental set up. Experiments were initiated in 2017 at the Gulf Coast Research Education Center (GCREC), (27°N, 82°W) and in Dover Florida (28°N, 82°W), to evaluate the efficacy of 426 kg ha^{-1} of Paladin Pic-21 EC, 280 kg ha^{-1} of Pic-Clor 60 EC and 224, 336, 448 and 560 kg ha^{-1} of EDN on weeds, nematodes and soil-borne pathogens. Soil type at GCREC was a Myakka fine sand (sandy, siliceous, hyperthermic, Aeric, Alaquods) with 1.5% organic matter, pH of 6.5, and sand, silt, clay content of 96, 3, and 1%, respectively. The soil in Dover is a Seffner fine sand (Sandy, siliceous, hyperthermic Quartzipsammentic Haplumbrepts) with a pH of 7.6 and <1% organic matter. All experiments were set up as randomized complete blocks with four reps. Each plot was 45.7 meters of a single bed.

Bed formation and fumigation occurred on August 22 and 23, 2017, at the GCREC and Dover, respectively. Beds were 30 cm tall at the peak, 66 cm wide on the bed top and spaced 1.22 m apart. Beds were covered with totally impermeable film (Berry Plastics, Evansville IN) immediately following fumigation. A single 16 mm diameter drip tape was laid in the center of the bed with emitters every 30 cm with a flow rate of 1.13 lph (Eurodrip USA Inc., Madera CA). All fumigants were injected through the drip tape. Pic-Clor 60 EC and Paladin Pic-21 EC were injected directly into the drip tape over a 30 minute period followed by adequate run time to completely flush the lines. EDN was injected using a 'mixer' to distribute the fumigant as small bubbles within the water. Strawberries plants of 'Florida Radiance' were transplanted October 10 and 16 at GCREC and Dover, respectively, at a spacing of 38 cm in two rows per bed. Fifty transplants were placed in each plot. Strawberries were irrigated, fertilized and managed for foliar pests according to industry standards for Florida production. Row middles were maintained by using industry standard herbicide treatments.

Results

No crop damage was observed in any of the plots at either site, and we conclude that all fumigant treatments were safe for use on strawberry. Total berry yield was substantially higher at GCREC where the plants were much healthier and were harvested for a slightly longer period of time. There were no significant yield differences between fumigant treatments at either site due in part to significant variability between plots (Table 1). There was a marginally significant interaction between site and fumigant effects on the number of dead plants but the trends are difficult to explain (Table 1). Plant death was caused by a number of pathogens including *Macrophomina phaseolina, Phytotphthora* species, and *Fusarium* species. There were no consistent difference between plots. There were no differences in nematode numbers.

The number of purple nutsedge shoots in each plot were relatively low. At both sites, all fumigants reduced purple nutsedge density compared to the nontreated control equally (Table 2). Total weed biomass was significantly lower following fumigation with EDN or Paladin Pic-21 versus the nontreated control or Pic-Clor 60.

At GCREC, EDN was the most effect fumigant treatment for *Macrophomina* control (Table 3). Few differences between fumigants were observed in the center of the bed at 7.6 cm but at deeper depths and on the bed edges EDN out-performed the other fumigants and adequately controlled this pathogen. The same trend was not observed at Dover where all fumigants worked equally well (Table 4). We were unable to collect consistent data from the infected strawberry crowns.

EDN applications increased ammonia levels at both sites compared to other fumigant treatments (Figure 1). At GCREC, ammonia levels were higher at higher EDN rates but rate differences disappeared rapidly. At Dover, EDN applications increased ammonia levels in the soil but there were no consistent effects of fumigant rate on soil ammonia levels. No consistent trend was noted with nitrate levels (Figure 2) and there were no trends with total nitrogen (data not shown).

Conclusions

We conclude that EDN is safe for use on strawberry. It is an effective management tool for *Macrophmina*, purple nutsedge and broadleaf and grass weeds. EDN application will increase ammonia levels in the soil but not necessarily nitrate levels. There does not appear to be an obvious trend between application rates and soil ammonia levels. Additional data is needed to verify activity on nematodes.

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Table 1. Effects of fumigation on total berry yield, sting nematode density, and percent plant death at Dover, Florida and the Gulf Coast Research and Education Center in Balm, Florida in 2017.

Fumigant	Rate	Total Berry Yield		Dead Plants		Sting Nematodes
		GCREC	Dover	GCREC	Dover	
	kg ha^{-1}	-------- kg ha^{-1}-------		------------%------------		# 200 cc soil^{-1}
Nontreated	-	43,277	12,699	8.1 bc[a]	10.3 bc	11.8
EDN Fumigas	224	-	11,095	-	9.4 bc	10.2
EDN Fumigas	336	64,577	15,182	8.9 bc	10.4 bc	12.5
EDN Fumigas	448	65,098	13,524	2.9 c	25.1 a	16.0
EDN Fumigas	560	54,209	13,383	10.6 bc	17.4 ab	13.0
Paladin Pic-21 EC	426	51,998	-	6.0 c	-	-
Pic-Clor 60 EC	280	55,564	7,879	5.5 c	22.1 a	9.8
P-value	-	0.3638	0.2754	0.0688		0.1

[a]Means followed by the same letter are not significantly different based on Tukey adjusted means comparisons at $p<0.05$.

Table 2. Effects of fumigation on nutsedge density averaged over time on strawberry beds at Dover, Florida and the Gulf Coast Research and Education Center in Balm, Florida in 2017.

Fumigant	Rate	Nutsedge Density		Weed Biomass
		GCREC	Dover	
	kg ha^{-1}	---------------# m^{-2}--------------		---kg ha^{-1}---
Nontreated	-	4 a[a]	2 a	76.6 a
EDN Fumigas	224	-	1 b	3.3 c
EDN Fumigas	336	2 b	1 b	7.8 bc
EDN Fumigas	448	2 b	0 b	7.3 c
EDN Fumigas	560	1 b	1 b	20.3 abc
Paladin Pic-21 EC	426	1 b	-	4.2 c
Pic-Clor 60 EC	280	2 b	1 b	62.5 ab
P-value	-	<0.0001	<0.0001	0.0657

[a]Means followed by the same letter are not significantly different based on Tukey adjusted means comparisons at $p<0.05$.

Table 3. Efficacy of fumigants applied to soil in a strawberry field at GCREC in Balm, FL in the 2017-18 strawberry season on inoculum of *M. phaseolina* at different depths

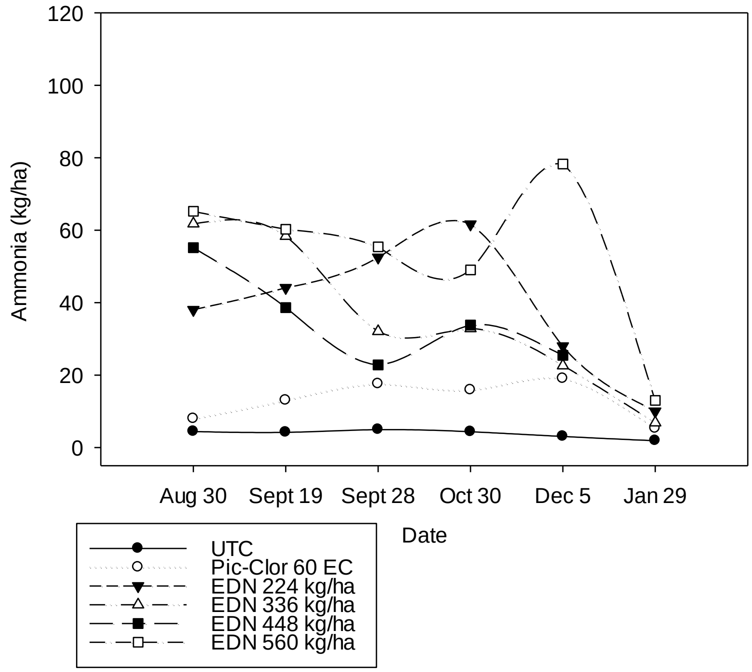
Treatments	Rate	*M. phaseolina* (CFU bag^{-1})			$Pr > F^z$	*M. phaseolina* (CFU g^{-1} crown)
		7.6 cm	20.3 cm	7.6 cm		7.6 cm
	kg ha^{-1}	center	center	side		side
1. Nontreated	-	1176.25a[y]	1143.75a	840.50ab	0.8020	415.0
2. Pic-Clor 60 EC	280	5.00b	199.67b	676.00b	0.0002	2.6
3. Paladin-Pic EC	426	27.50b	1642.50a	1846.25a	<0.0001	31.5
4. EDN 336	336	1.00b	0.50c	17.25c	0.1131	668.9
5. EDN 448	448	0.33b	0.33c	1.33c	0.8731	975.9
6. EDN 560	560	0.25b	0.25c	0.25c	1.0000	15.0
P value		<0.0001	<0.0001	<0.0001	-	0.5724

[y] Treatments followed by the same letter within a column are not significantly different according to the Fisher's Protected LSD test ($p \leq 0.05$) on squareroot transformed data. Non-transformed means are presented.
[z] Probability associated with test of effect slices for local*treatment interaction, sliced by treatment.

Table 4. Efficacy of fumigants applied to soil in a strawberry field at FSGA research facility in Dover, FL in the 2017-18 strawberry season on inoculum of *M. phaseolina* at different depths

Treatments	Rate	*M. phaseolina* (CFU bag^{-1})			$Pr > F^z$	*M. phaseolina* (CFU g^{-1} crown)
		7.6 cm	20.3 cm	7.6 cm		7.6 cm
	kg ha^{-1}	center	center	side		side
1. Nontreated	-	992.0a	573.5a	923.8a [y]	0.9070	1034.1
2. Pic-Clor 60 EC	280	0.5b	0.33b	440.0ab	0.1991	99.3
3. EDN	224	0.5b	0.5b	451.25ab	0.0278	1572.9
4. EDN	336	0.5b	0.5b	370.0ab	0.0321	0.0
5. EDN	448	2.0b	1.0b	355.33ab	0.2996	1071.4
6. EDN	560	1.25b	0.0b	0.75b	0.9158	7.7
P value		<0.0001	0.001	0.1525	-	0.0508

[y] Treatments followed by the same letter within a column are not significantly different according to the Fisher's Protected LSD test ($p \leq 0.05$) on squareroot transformed data. Non-transformed means are presented.
[z] Probability associated with test of effect slices for local*treatment interaction, sliced by treatment.



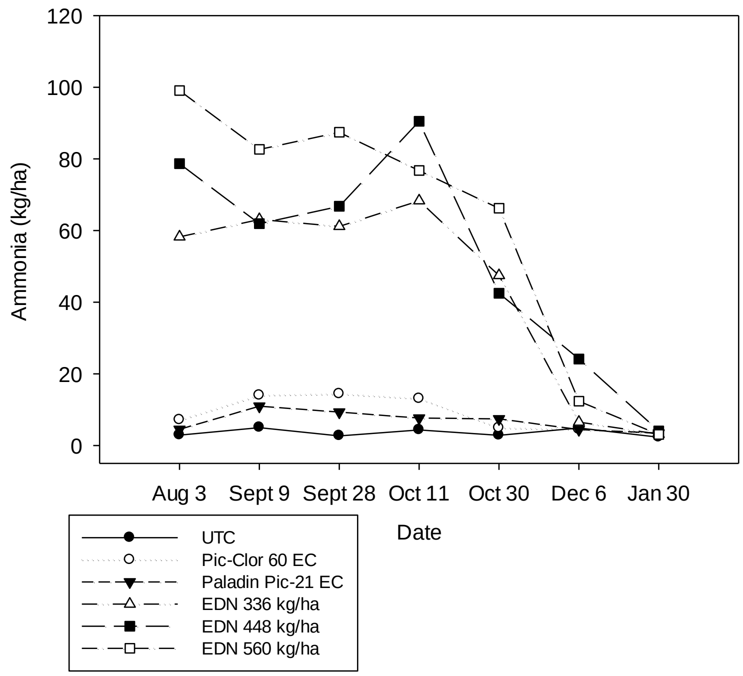
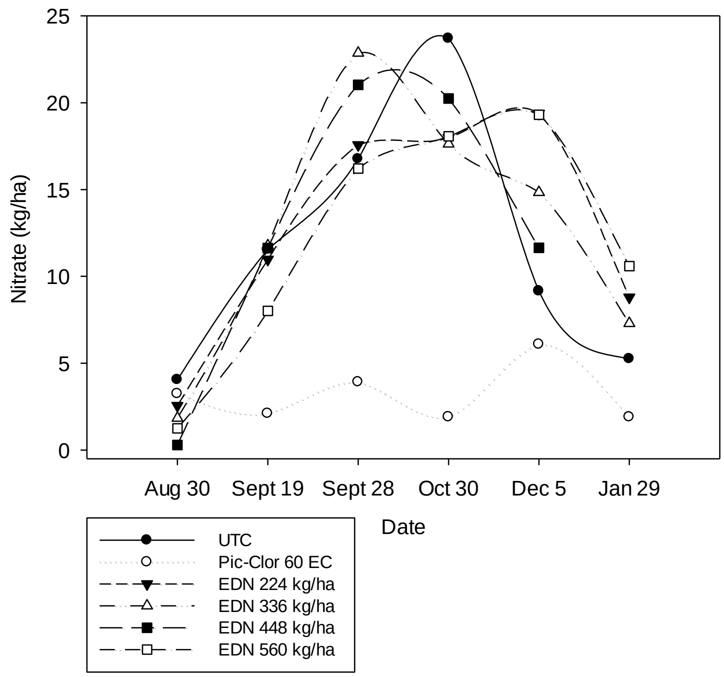


Figure 1. Soil Ammonia in the bed following fumigation over the strawberry season at Dover (top), Florida and at the Gulf Coast Research and Education Center in Balm (bottom), Florida, in 2017-2018.



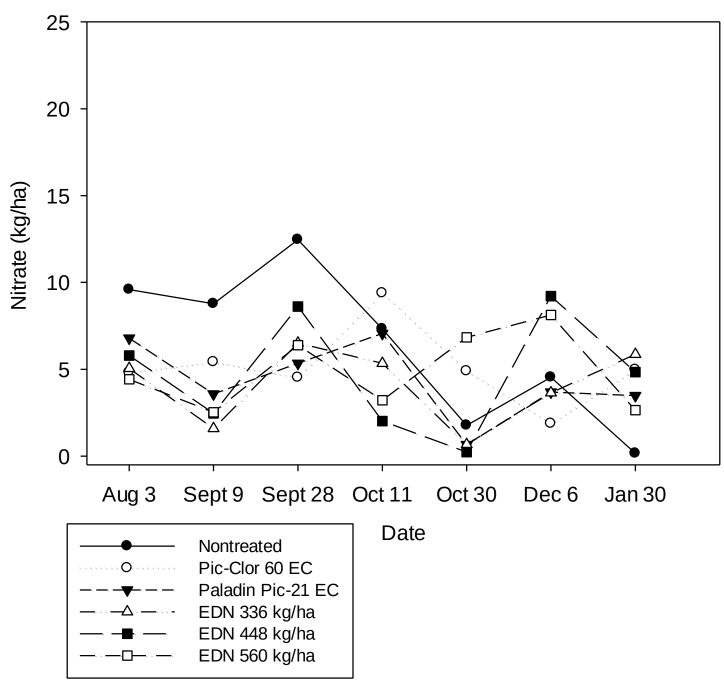


Figure 2. Soil nitrate in the bed following fumigation over the strawberry season at Dover (top), Florida and at the Gulf Coast Research and Education Center in Balm (bottom), Florida, in 2017-2018.