TOMATO NUTRIENT ABSORPTION AND NUTSEDGE AND STING NEMATODE MANAGEMENT WITH PROPYLENE OXIDE

BIELINSKI M. SANTOS* AND JAMES P. GILREATH
University of Florida, IFAS
Gulf Coast Research and Education Center
14625 County Road 672
Wimauma, FL 33598

Additional index words. Lycopersicon esculentum, soil fumigant, sting nematode, Belonolaimus, Cyperus, tomato fertility, propozone

Abstract. Among the current methyl bromide alternatives under
study, propylene oxide has shown potential to control soilborne
diseases, nematodes, and weeds in polyethylene-mulched tomato (Lycopersicon esculentum Mill.). However, further
research is needed to determine the appropriate application
rates to control sting nematode (Belonolaimus spp.) and nutfedge (Cyperus spp.) in the crop. Also, the effect of
these pests on tomato nutrient absorption has not been deter-
mind yet. Therefore, field trials were conducted to determine
the most effective application rates against these pests and
their effect on nutrient uptake. Propylene oxide rates were 0,
190, 380, 570, 760, and 950 L·ha⁻¹. Data indicated that sting
nematode and nutfedge populations rapidly decreased with
570 L·ha⁻¹ of propylene oxide. For P and K foliar content, there
was a linear increase of P concentration as rate increased,
whereas K concentration increased rapidly after 190 L·ha⁻¹ of
propylene oxide. The highest tomato yields were obtained with
application of 760 and 950 L·ha⁻¹ of propylene oxide.

Propylene oxide is an all-purpose fumigant that has pro-
vided broad-spectrum control against soilborne diseases,
nematodes, and weeds in preliminary tests (Belcher et al.,
2004; López-Aranda et al., 2004; Norton, 2004). This mole-
cule has been used over 40 years as an “insecticidal fumigant”
in stored food and to sterilize soils (Warren, 2004). After soil
application, it is microbially-decomposed and transformed to
propylene glycol, a food additive (Warren, 2004).

Sting nematode (Belonolaimus spp.) and nutfedges (Cyperus
spp.) are among the most common pests in polyethylene-
mulched tomato, which have been effectively controlled by
methyl bromide (MBr) during the last 30 years. However,
MBr is being phased out because it is an ozone-depleting mol-
ecule (US-EPA, 1999). The current search for MBr replace-
ments has led researchers to investigate propylene oxide’s
broad-spectrum properties against the most common soil-
borne pests in vegetable fields. However, the appropriate
application rates for successful nematode and nutfedge control
in polyethylene-mulched tomato have not been examined. At
the same time, it is well-know that nematode galling and weed
competition can severely limit crop nutrient absorption, thus
reducing fruit yield and quality. Little research has been con-
ducted to address the joint effect of nematodes and weeds on
foliar nutrient concentration. Therefore, the objectives of
this study were: a) to determine the response of sting nema
tode and nutfedge populations to propylene oxide rates, and
b) to examine the influence of nematode and nutfedge pop-
ulations on tomato foliar nutrient concentration.

Materials and Methods

A field trial was conducted during spring 2004 at the Gulf
Coast Research and Education Center in Bradenton, Fla.
Research plots were located on an EauGallie fine sand spodo-
sol, with pH 6.3 and organic matter content <2%. The exper-
imental site has a history of heavy nematode and nutfedge
infestations. Based on previous soil analysis and crop nutri-
tional requirements, the fields received a broadcast appli-
cation of 285 kg·ha⁻¹ of 15N-0P-25K as starter fertilizer
(Maynard et al., 2003). Prior to treatment establishment, the
plots were disked twice before planting bed formation.

Propylene oxide rates were 0, 190, 380, 570, 760, and 950
L·ha⁻¹. Treatments were arranged in a randomized complete
block design with six replications. Planting beds were 80 cm
wide at the base, 70 cm wide at the top, 20 cm high, and
spaced 150 cm apart on centers. Experimental units were 9.1
m long. On the day of fumigant injection, planting beds were
formed, pressed and injected 15 to 20 cm deep with propy-
lene oxide using a N-propelled fumigation rig with three chis-
els per bed. Each chisel was spaced 30 cm apart.

After fumigant application, beds were pressed and cov-
ered with low-density polyethylene film (0.038 mm thick; Pli-
ant Corp., Schaumburg, Ill.). Two drip irrigation lines were
placed 30 cm apart under the mulch film and buried 2.5 cm
deep. Emitters were spaced every 30 cm. Drip irrigation was
provided daily and N and K were supplied to the crop by daily
applications, insecticides and fungicides were applied as necessary
beginning 1 week after transplanting (WAT) (Maynard et al.,
2003).

Nematode populations were determined 14 WAT by ex-
tracting soil samples with a soil probe (2.5 cm wide by 20 cm
deep) from the rhizosphere of 10 tomato plants per plot, and
the nematodes were separated and counted from 100 cm³ soil
using a standard sieving and centrifugation procedure (Jen-
kins, 1964). At the same time, ten fully-developed mature
leaves in each experimental unit were collected for foliar nutri-
trient concentration. Nutedge population on the top of each
bed was counted at 4, 8, and 14 WAT. Tomato plant vigor was
evaluated visually 10 WAT using a percentage scale where
100% represented optimum plant vigor and 0% indicated
plant death. Marketable tomato fruits were harvested twice
(12 and 14 WAT). Treatment effects on each variable were
analyzed with regression analysis (P = 0.05) to characterize
the relationship between propylene oxide rate and the re-
sponse variable (SAS Institute, 2000).

*Corresponding author; e-mail: bmsantos@ifas.ufl.edu
Results and Discussion

At 4, 8, and 14 WAT, nutsedge densities decreased as propylene oxide increased (Fig. 1). At 4 WAT, a negative logarithmic equation characterized the response for nutsedge to the fumigant \[y = 67.13 - 10.24 \ln(x)\]. At that sampling time, applying 190 L·ha\(^{-1}\) of propylene oxide resulted in approximately 80% weed control, based on the equation predicted values. However, as time between observations increased, higher propylene oxide rates were needed to achieve effective nutsedge control. For instance, 80% nutsedge control was obtained with approximately 775 and 850 L·ha\(^{-1}\) of propylene oxide, with negative quadratic equations describing the weed response (\[y = 75.75 - 0.0314x - 0.00006x^2\], and \[y = 85.32 + 0.0130x - 0.00011x^2\], for 8 and 14 WAT, respectively). These results indicate that relatively high propylene oxide rates are needed for effective season-long nutsedge control.

Sting nematode populations decreased as propylene oxide rate increased, with an exponential model \[y = 0.80 + 25.70e^{-x/96.1828}\] characterizing the effect of the fumigant on the nematode (Fig. 2). In comparison with the non-treated control, the addition of propylene oxide at 190 L·ha\(^{-1}\) sharply reduced sting nematode counts from approximately 26.5 to 4.4/100 mL soil, with further reductions as rate approached 950 L·ha\(^{-1}\).

Tomato foliar concentrations of P and K were influenced by propylene oxide rates (Fig. 3). The concentrations of both nutrients increased with propylene oxide rates. However, two distinct models characterized these responses. For foliar P concentration, there was a linear response to the fumigant rates (\[y = 0.31 + 0.0002x\]), ranging from 0.31 to 0.51%; whereas, a logarithmic model characterized foliar K concentration \[y = 0.72 - 0.37 \ln(x)\], which ranged between 2.38 to 3.25%.

Tomato plant vigor (data not shown) and total marketable yield were directly correlated \((r = 0.90)\), which indicated that visual assessment of plant growth reflected the yield trend at harvest. Marketable yield rapidly increased \([y = -14.97 + 5.52 \ln(x)]\) with propylene oxide rates between 0 and 190 L·ha\(^{-1}\) (Fig. 4). In comparison with the non-treated control, fumigant rates of 760 and 960 L·ha\(^{-1}\) increased tomato yield between 4.1 and 3.5 times, respectively, with no statistical difference between these two values.

In summary, propylene oxide rates of at least 760 L·ha\(^{-1}\) can effectively control sting nematode and nutsedge populations, resulting in higher tomato yields. The data also demonstrated that both sting nematode root pruning and nutsedge...
nutrient competition could interfere with P and K absorption, as revealed by the tomato foliar nutrient concentrations. The economic feasibility of propylene oxide applications might determine the future of this molecule as a MBr alternative for polyethylene-mulched vegetable crop production in Florida’s sandy soils.

Literature Cited


Fig. 4. Effect of propylene oxide rates on tomato yield. Bradenton, Florida, 2004.