Impact of Chloropicrin on Nutsedge Emergence through Polyethylene Mulch

Bielinski M. Santos, James P. Gilreath, and Timothy N. Motis[1]

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Summary. Field trials were conducted from 1999 to 2003 to determine whether chloropicrin (Pic) stimulates nutsedge (*Cyperus* spp.) emergence through polyethylene mulch, and to examine at which Pic rate the stimulatory effect is maximized. Shank-injected Pic rates were 0, 50, 100, 150, 200, and 250 lb/acre. Application rates between 107 and 184 lb/acre of Pic stimulated nutsedge sprouting through polyethylene mulch by 60%, 400%, 58%, and 120% more than the nontreated control during four of the seasons. Rates above 250 lb/acre eliminated the stimulatory effect on nutsedge, reducing densities to the same levels as the nontreated control. The exact physiological mechanism of this stimulation is still unknown.

Yellow and purple nutsedge (*Cyperus esculentus* and *C. rotundus*, respectively) are among the 10 most noxious weeds throughout the world (Holm et al., 1977). Previous research has indicated that nutsedge interference can reduce bell pepper (*Capsicum annuum*), tomato (*Lycopersicon esculentum*), radish (*Raphanus sativus*), and cilantro (*Coriandrum sativum*) yields by 22%, 51%, 100%, and 61%, respectively (Gilreath and Santos, 2005; Gilreath et al., 2005; Morales-Payan et al., 1997; Santos et al., 1998).

In polyethylene-mulched crops, soil fumigation with methyl bromide (MBr) has been critical to manage these weeds. However, after MBr phase-out, nutsedge management in polyethylene-mulched vegetable crops is challenging because of the lack of a MBr alternative that could consistently control these weeds (Gilreath et al., 1994, 1996, 1997, 1999; U.S. Environmental Protection Agency, 1999).

The fumigant Pic is a clear liquid under pressure and becomes a gas when injected in the soil. Although Pic has strong activity against soilborne fungi, it is seldom applied alone because it does not always provide adequate nematode and nutsedge control (Hutchinson et al., 2000; Locascio et al., 1997, 1999; Sumner et al., 1997). Commercial formulations of MBr and many of its chemical alternatives contain Pic. For instance, an application rate of 350 lb/acre of MBr + Pic (67:33 v/v) has almost 116 lb/acre of Pic.

Locascio and Dickson (2000) suggested that Pic may stimulate nutsedge emergence, increasing nutsedge population from 630 and 980 shoots/ha when the Pic proportion changed from 17% to 35% in a 1,3-dichloropropene (1,3-D) + Pic mixture. Routine observations in mulched-tomato and bell pepper fields have also led to the hypothesis that Pic might stimulate nutsedge emergence. Therefore, with the increasing Pic use in MBr alternative treatments, nutsedge control becomes a major concern. This research was conducted to: 1) determine whether Pic stimulates nutsedge emergence through polyethylene mulch, and 2) examine at which Pic rate the stimulatory effect is maximized.

Materials and methods

Six field trials were conducted during two spring seasons (1999 and 2003) and four fall seasons (1999, 2000, 2001, and 2002) at the Gulf Coast Research and Education Center in Bradenton, Fla., on an EauGallie fine sand, with organic matter content <2%. The experimental site has a history of heavy nutsedge infestations of both nutsedge species (>10 plants/ft^2). Treatments were 0, 50, 100, 150, 200, and 250 lb/acre of Pic. Each treatment was either replicated four (Spring 1999) or six (all fall seasons and Spring 2003) times and arranged in a randomized complete-block design.

In Fall 1999 and 2000, and Spring 2003, experimental units were 30 by 2.33 ft (70 ft^2), whereas during the remaining seasons, these were 40 by 2.33 ft (93.2 ft^2). Application of Pic occurred on 2 Mar. 1999, 9 Sept. 1999, 12 Sept. 2000, 27 Sept. 2001, 17 Sept. 2002, and 29 Jan. 2003. The fumigant was injected 6 to 8 inches deep into the finished beds using a N-propelled three-chisel per bed fumigation rig, with each chisel spaced 1 ft apart. Immediately following application of Pic, bed tops were covered with 3-mil-thick low-density polyethylene film (white in fall; black in spring, according to local practices).

Emerged nutsedge shoots through the bed tops were counted at least twice each season for the total area of the experimental units. Season by Pic rate interaction for weed data was examined with analysis of variance at 5% significance level (SAS version 8; SAS Institute, Cary, N.C.). Within each season, nutsedge density responses to Pic rate were described with regression analysis. Maximum predicted nutsedge densities were determined by equaling to zero the first derivative of each regression curve and solving for the corresponding Pic rate.

Results and discussion

There were significant season by Pic rate interactions for densities of both nutsedge species. Therefore, each season will be discussed separately. During all seasons, with the exception of Fall 2001, there was considerable nutsedge pressure (≥1 plant/ft^2) in the experimental site. Therefore, the effect of Pic rate will be described

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[1]Horticultural Research Associate, Weed Science Professor, and Former Research Associate, respectively, Gulf Coast Research and Education Center, University of Florida, 14625 County Rd. 672, Wimauma, FL 33598; e-mail: bmsantos@ifas.ufl.edu

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.3048	ft	m	3.2808
0.0929	ft^2	m^2	10.7639
1.1209	lb/acre	kg·ha^{-1}	0.8922
0.0254	mil	mm	39.3701

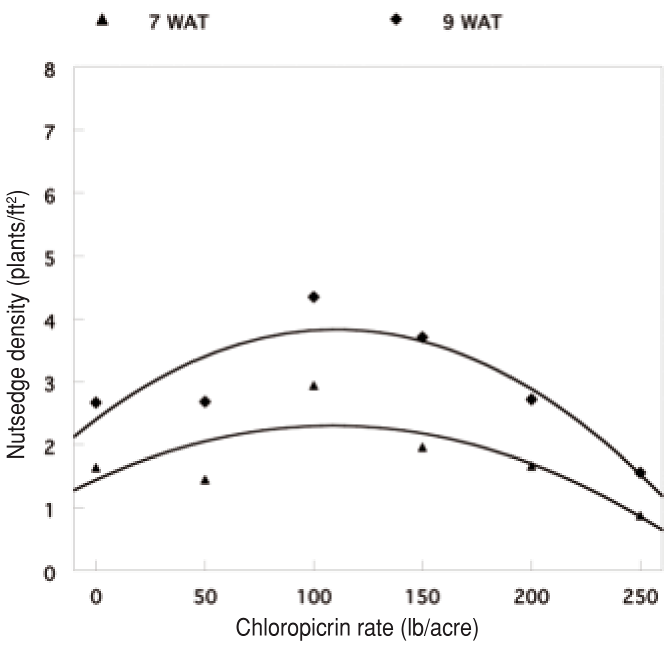

Fig. 1. Effect of chloropicrin (Pic) rates on nutsedge emergence through polyethylene mulch at 7 and 9 weeks after treatment (WAT) during the Spring 1999 season. Regression equations are $y = 1.45 + 0.1403x - 0.000576x^2$ and $y = 2.40 + 0.2319x - 0.000939x^2$, for 7 and 9 WAT, respectively (1 lb/acre = 1.1209 $kg \cdot ha^{-1}$, 1 ft^2 = 0.0929 m^2).

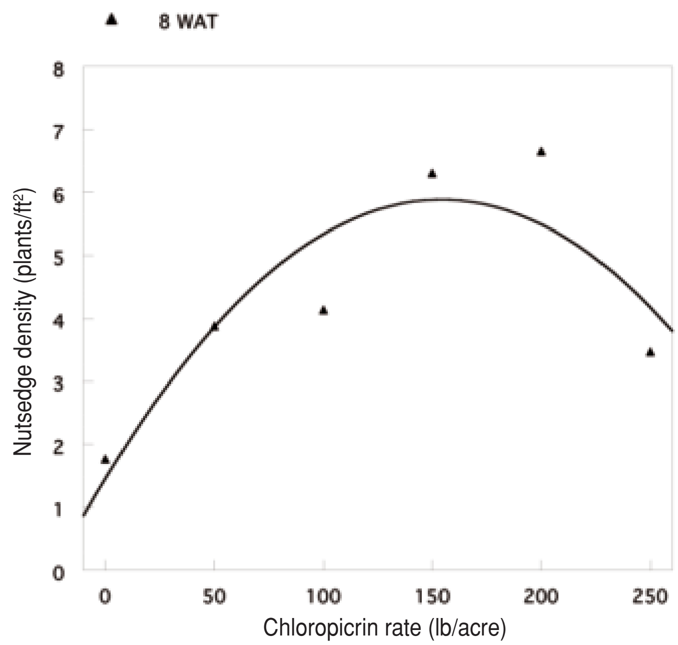

Fig. 2. Effect of chloropicrin (Pic) rates on nutsedge emergence through polyethylene mulch at 8 weeks after treatment (WAT) during the Fall 1999 and 2000 seasons. Regression equation is $y = 1.46 + 0.5138x - 0.001488x^2$ (1 lb/acre = 1.1209 $kg \cdot ha^{-1}$, 1 ft^2 = 0.0929 m^2).

only for the remaining five seasons. During those seasons, there was no emergence difference between both nutsedge species.

In Spring 1999, there were no significant Pic rate effects on weed densities at 2 and 4 weeks after treatment (WAT) (data not shown). However, at 7 and 9 WAT, nutsedge density response to Pic rate fit a quadratic model, where the regression equations were

$y = 1.45 + 0.1403x - 0.000576x^2$ and

$y = 2.40 + 0.2319x - 0.000939x^2$,

for 7 and 9 WAT, respectively (Fig. 1). Maximum predicted nutsedge densities (2.3 and 3.8 plants/ft^2) occurred at Pic rates of 107 and 109 lb/acre. Based on these equations, these weed densities were 59% and 60% higher than those for the nontreated plots.

A similar regression model was applied for the weed densities during the Fall 1999 and 2000 seasons. Therefore, these two seasons were combined for analysis. There was no significant Pic rate effect on nutsedge populations at 4 WAT. However, at 8 WAT, the quadratic regression was

$y = 1.46 + 0.5138x - 0.001488x^2$,

with maximum weed emergence (5.9 plants/ft^2) occurring with 152 lb/acre of Pic, which was more than four times higher than the nontreated control (Fig. 2).

During Fall 2002, Pic rates had a less dramatic effect on nutsedge densities than in the preceding seasons. Although there was Pic rate effect on weed emergence at 2 and 3 WAT, Pic rates stimulated weed sprouting at 5 WAT. This effect was described by the quadratic equation

$y = 12.96 + 0.7240x - 0.001731x^2$

(Fig. 3). A rate of 184 lb/acre of Pic had the highest nutsedge density (20.5 plants/ft^2), which was 58% higher than the weed density of the non-fumigated control. A similar situation occurred at 9 WAT (data not shown).

For Spring 2003, there was no significant Pic rate influence on weed emergence during the first 2 WAT. However, at 3 and 10 WAT, nutsedge populations were stimulated with Pic application (Fig. 4). The regression equations were

$y = 0.96 + 0.1465x - 0.000466x^2$ and

$y = 3.36 + 0.2778x - 0.000856x^2$

for each sampling time. Maximum predicted Pic effect occurred with 138 and 143 lb/acre at 3 and 10 WAT, respectively, resulting in weed densities of 2.1 and 5.6 plants/ft^2. These nutsedge densities were 120% and 67% higher than the density in the nontreated control.

In summary, during five growing seasons, Pic application rates between 107 and 184 lb/acre stimulated nutsedge sprouting through polyethylene mulch. These application rates are common in practical field situations, where polyethylene-mulched vegetable crops are grown on beds fumigated with commercial formulations that combine Pic with either MBr or 1,3-D. Increasing Pic rates beyond 200 lb/acre reduced nutsedge densities to nearly the same levels as the nontreated control. This finding suggested lack of efficacy of this fumigant on nutsedge species. The exact physiological mechanism of the sprouting stimulation is still unknown. These results might provide a valuable means to manage fields with high nutsedge densities. For instance, Pic could be used to stimulate nutsedge emergence a few days before the application of drip-applied fumigants with herbicidal activity, such as 1,3-D, metam sodium, and metam potassium. This situation could cause nutsedge to emerge in unusually high densities at the beginning of the growing season, allowing fumigants and herbicides to have a more satisfactory performance against these weeds.

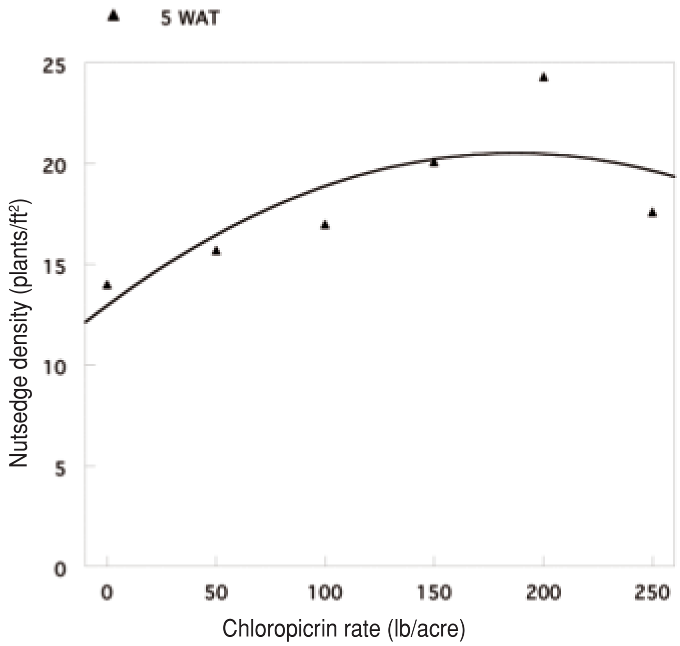

Fig. 3. Effect of chloropicrin (Pic) rates on nutsedge emergence through polyethylene mulch at 5 weeks after treatment (WAT) during the Fall 2002 season. Regression equation is $y = 12.96 + 0.7240x - 0.001731x^2$ (1 lb/acre = 1.1209 kg·ha^{-1}, 1 ft^2 = 0.0929 m^2).

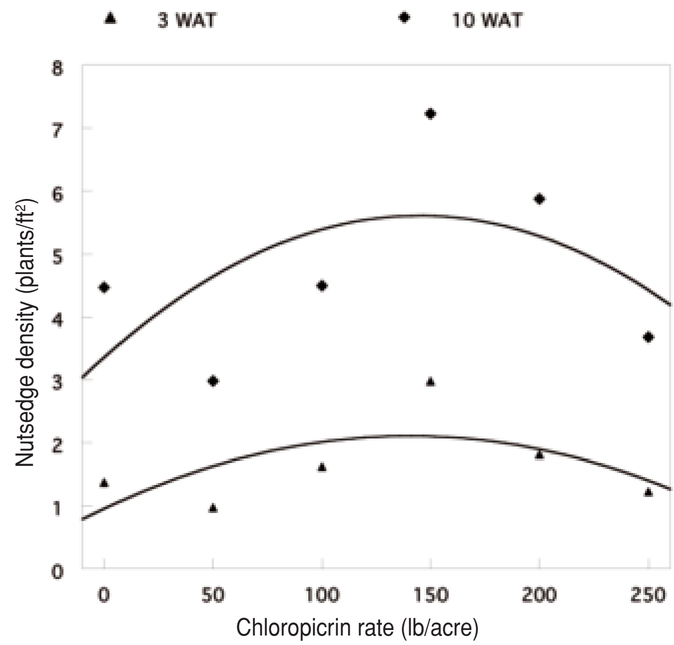

Fig. 4. Effect of chloropicrin (Pic) rates on nutsedge emergence through polyethylene mulch at 3 and 10 weeks after treatment (WAT) during the Spring 2003 season. Regression equations are $y = 0.96 + 0.1465x - 0.000466x^2$, and $y = 3.36 + 0.2778x - 0.000856x^2$, for 3 and 10 WAT, respectively (1 lb/acre = 1.1209 kg·ha^{-1}, 1 ft^2 = 0.0929 m^2).

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