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Nutsedge (*Cyperus* spp.) Control in Bell Pepper (*Capsicum annuum*) Using Fallow-Period Weed Management and Fumigation for Two Years

M. Ryan Miller, Peter J. Dittmar, Gary E. Vallad, and Jason A. Ferrell*

Integrated management programs are becoming increasingly necessary for nutsedge control in the absence of methyl bromide. In 2012, field studies were established and maintained for a period of 2 yr at two locations to evaluate the additive effect of fallow programs and preplant fumigants for nutsedge control in bell pepper. The study included eight fallow programs consisting of eight combinations of glyphosate (G) and cultivation (C), and two fumigants; 1,3-dichloropropene + chloropicrin, dimethyl-disulfide + chloropicrin, and a nontreated check. All fallow programs provided greater late-season control of nutsedge compared to the nontreated, with the greatest control of nutsedge observed with glyphosate fb (followed by) glyphosate (GG) and glyphosate fb cultivation fb glyphosate (GCG) fallow programs. Fumigation provided additional nutsedge control in single-input fallow programs. Increased marketable yield was observed in 2012 with the application of either fumigant compared to a nonfumigated control. Furthermore, increased marketable yield was observed with more intensive fallow programs in 2013. Nutsedge control in bell pepper was significantly increased when a fallow program was used in combination with other weed-management practices.
Nomenclature: 1,3-dichloropropene; chloropicrin; dimethyl-disulfide; glyphosate; purple nutsedge, *Cyperus rotundus* L.; yellow nutsedge, *Cyperus esculentus* L.; bell pepper, *Capsicum annuum* L.
Key words: Cultivation, fallow weed control, fumigation, integrated pest management, methyl bromide alternative.

Los programas de manejo integrado se están convirtiendo en una necesidad para el control de *Cyperus* spp. en ausencia de methyl bromide. En 2012, se establecieron estudios de campo en dos localidades y se mantuvieron por un período de 2 años para evaluar el efecto aditivo de programas de barbecho y fumigantes pre-siembra para el control de *Cyperus* spp. en pimentón. El estudio incluyó ocho programas de barbecho consistiendo de ocho combinaciones de glyphosate (G) y cultivación (C), y dos fumigantes: 1,3-dichloropropene + chloropicrin, dimethyl-disulfide + chloropicrin, y un testigo no-tratado. Todos lo programas de barbecho brindaron mayor control al final de la temporada de crecimiento al compararse con el testigo no-tratado, observándose el mayor control de *Cyperus* spp. en los programas de barbecho con glyphosate fb (seguido de) glyphosate (GG) y glyphosate fb cultivación fb glyphosate (GCG). La fumigación brindó un control adicional de *Cyperus* spp. en sistemas de barbecho con un solo insumo. En 2012, se observó un aumento en el rendimiento comercializable con la aplicación de cualquiera de los fumigantes al compararse con el testigo no-fumigado. Adicionalmente, se observó un incremento en el rendimiento comercializable con programas de barbecho más intensivos en 2013. El control de *Cyperus* spp. en pimentón fue significativamente incrementado cuando se usó un programa de barbecho en combinación con otras prácticas de manejo de malezas.

Commercial bell pepper production relies on a raised-bed plasticulture system that utilizes polyethylene mulch for production. Webster (2005) reported that although the polyethylene can suppress some broadleaf and grass weeds, purple and yellow nutsedge can pierce through the mulch. Season-long interference of 5 yellow nutsedge plants m^{-2} reduced bell pepper yield 10%, and a population of 63 purple nutsedge plants m^{-2} reduced bell pepper yield 10% (Motis et al. 2003, 2004). In the past, nutsedge control was achieved with methyl bromide fumigation. However, methyl bromide was removed from agricultural production due to ozone depletion (EPA 2011). Methyl bromide alternatives for nutsedge control include herbicides, cultural practices, and fumigation.

The summer conditions in Florida discourage bell pepper production during this time due to increased

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* First and second authors: Graduate Student and Assistant Professor, Department of Horticultural Sciences, University of Florida, Gainesville, FL 32611; third author: Assistant Professor, Department of Plant Pathology, University of Florida/IFAS Gulf Coast Research and Education Center, Wimauma, FL 33598; fourth author: Professor, Department of Agronomy, University of Florida, Gainesville, FL 32611. Corresponding author's E-mail: michaelrmiller@ufl.edu

pest and disease pressures; thus, fields are planted with a cover crop or left fallow. This fallow period allows for the application of nonselective herbicides and/or cultivation. Glyphosate is a widely used herbicide in vegetable production due to its low cost, low toxicity, and high level of weed control. Glyphosate is effective when applied to the nutsedge foliage because it is translocated throughout the entire plant (Sprankle et al. 1975). Previous research found that 20% of the glyphosate applied to the foliage of nutsedge is translocated to the underground tubers (Zandstra and Nishimoto 1977). Tubers from 6-wk-old purple nutsedge plants did not resprout after an application of glyphosate; however, 5% of tubers from 12-wk-old plants resprouted after being treated with glyphosate (Zandstra and Nisimoto 1977). Furthermore, glyphosate at 2.57 kg ae ha^{-1} effectively reduced nutsedge tuber biomass by 75% (Webster et al. 2008). Although glyphosate provides control of nutsedge when applied POST, PRE activity of glyphosate is nonexistent because it irreversibly binds to soil particles (Sprankle et al. 1975). Currently, application timing of glyphosate in bell pepper is restricted to a "burn-down" application during the fallow season prior to planting (Santos et al. 2013).

In terms of mechanical control, cultivation alone has the potential to control $\leq$ 97% of nutsedge tubers (Hauser et al. 1962). Cultivation 10 cm deep every 3 wk between mid-March and July lowered purple nutsedge density to 750 tubers m^{-2}, compared to a no cultivation control during the same time period which had a density of 1,685 tubers m^{-2} (Bangarwa et al. 2008). Although nutsedge control can be achieved with cultivation; eradication with cultivation alone is impractical. Smith and Mayton (1938) found complete eradication of purple nutsedge required disking every 2 wk for more than a year.

Soil fumigation remains an integral part of Florida vegetable growers' pest management programs. Most Florida bell pepper and tomato growers have transitioned from methyl bromide for preplant soil fumigation to alternative products containing 1,3-dichloropropene + chloropicrin (1,3-D + Pic) (Snodgrass et al. 2012). Webster et al. (2001) reported 1,3-D + Pic in bell pepper provided early season control of purple nutsedge. However, by the end of season, purple nutsedge density was similar to the nontreated control. Dimethyl-disulfide (DMDS) is another soil fumigant registered for use in Florida vegetable crops (Anonymous 2012). McAvoy and Freeman (2013) reported DMDS reduced nutsedge populations from 79 shoots m^{-2} in the nontreated to 3 nutsedge m^{-2} when DMDS was applied at 561 L ha^{-1} underneath a totally impermeable film (TIF) mulch.

When mechanical and chemical control methods were combined, after a single fallow season, the use of glyphosate followed by cultivation followed by glyphosate in tomato decreased the number of nutsedge tubers to 15.2 tubers per sample compared to 24.7 to 26.8 tubers per sample in the nontreated, cultivation-alone, and glyphosate-alone fallow programs (Alves et al. 2013). The objective of this research was to assess the additive effect of combinations of cultivation and glyphosate applied during the fallow period in subsequent years and fumigant applications under the polyethylene mulch for managing nutsedge populations in bell pepper production.

Materials and Methods

Field studies were conducted at the Plant Science Research and Education Unit in Citra, FL, and the Gulf Coast Research and Education Center in Balm, FL. Plots were established in 2012 and maintained through 2013 to quantify the effect of fallow period treatments on nutsedge populations over time. The soil type at the Citra site was a Hague sand (Loamy, Siliceous, semiactive, Hyperthermic Arenic Hapludalfs) with a pH of 7, and the soil type at the Balm site was a Myakka fine sand (Siliceous Hyperthermic Oxyaquic Alorthod) with a pH of 7.

A factorial experiment was conducted with eight fallow programs and three fumigation systems. The experimental plots were arranged in a randomized complete block within a split-plot design, with fallow program as the main treatment and fumigation system as the subplot factor with four replications for each treatment combination. At Citra, main plots measured 8.5 by 15 m and the initiation of the study began after the initial cultivation of all plots, which occurred on February 20, 2012 (Table 1). At Balm, main plots measured 8.5 by 23 m with initiation of the study occurring

Table 1. Timing of glyphosate application (G) or cultivation (C) during eight different fallow-period weed management programs in 2012 and 2013 at Balm and Citra, FL. Fallow programs were applied to the same plot area during the 2 yr at both locations.

	Balm		Citra		Fallow program							
Wk	2012	2013	2012	2013	C[a]	G	CC	GG	CG	GC	GCG	NT
0	March 5	February 20	February 20	February 8				Initial cultivation				
4	April 2	March 19	March 19	March 5	—	—	—	—	—	—	G	—
6	April 16	April 2	April 2	March 20	—	—	C	G	C	G	—	—
9	May 7	April 23	April 23	April 9	C	G	—	—	—	—	C	—
12	May 28	May 14	May 14	May 2	—	—	C	G	G	C	—	—
14	June 11	May 28	May 28	May 14	—	—	—	—	—	—	G	—
8	July 9	June 24	June 25	June 10				Final cultivation				
22	August 8	July 26	July 23	July 16				Fumigation				
26	September 3	August 26	August 22	August 21				Planting				

[a] Abbreviations: C, cultivation; G, glyphosate; CC, cultivation followed by (fb) cultivation; GG, glyphosate fb glyphosate; CG, cultivation fb glyphosate; GC, glyphosate fb cultivation; GCG, glyphosate fb cultivation fb glyphosate; NT; nontreated.

after the initial cultivation of all plots on March 5, 2012.

The fallow program was an 18-wk period; treatments separated the fallow period in halves, thirds, and quarters (Table 1). Glyphosate application or cultivation occurred 4, 6, 9, 12, and 14 wk after initial cultivation (WAC). Fallow treatments included cultivation (C), glyphosate (G), cultivation followed by (fb) cultivation (CC), glyphosate fb glyphosate (GG), cultivation fb glyphosate (CG), glyphosate fb cultivation (GC), glyphosate fb cultivation fb glyphosate (GCG), and a nontreated check (NT). Glyphosate (Roundup Weathermax;® Monsanto, St. Louis, MO) at 5.5 kg ha^{-1} was applied with a CO_2-pressurized backpack sprayer calibrated to deliver 284 L ha^{-1}. Cultivation treatments were conducted with a tractor-attached rototiller to a depth of 12 cm.

At 18 WAC, all plots were cultivated to prepare the soil for bed formation, and weeds were allowed to decompose so plant debris wouldn't interfere with fumigation. Beds were formed and fumigated at 22 WAC. Fumigant treatments were shank-applied during bed formation and consisted of 1,3-dichloropropene + chloropicrin (40 : 60) at 337 kg ai ha^{-1} (PicClor 60;® Trical Inc., Hollister, CA), dimethyl-disulfide + chloropicrin (79 : 21) at 595 kg ai ha^{-1} (TriEst Ag, Plant City, FL), or a nonfumigated check. All fumigants were premixed by the supplier. Chloropicrin is the active ingredient in tear gas and was added to serve as a detector in case of a leakage in the fumigation rig during the fumigation process. Chloropicrin also can provide some control of fungi and insects. Immediately following fumigation, napropamide at 2.25 kg ai ha^{-1} was applied to preformed beds for grass and broadleaf control. Beds were then covered with a 1.25 mm polyethylene mulch (Blockade VIF; Berry Plastics Corporation, Evansville, IN). A total of three beds (subplots) were pressed in each main plot on 1.8 m spacing. In 2012, halosulfuron at 53 g ai ha^{-1} was applied at both locations over the top of the polyethylene mulch prior to planting to reduce nutsedge density so transplant holes could be created in the polyethylene mulch. In 2013, bed tops were mowed to reduce nutsedge to a height of 15 cm for the same purpose.

After the fumigation preplant interval, 30 bell pepper 'TomCat' plants were transplanted within the center 4.5 m of each subplot using a 30.4-cm offset double row plant spacing. Transplanting occurred on August 22, 2012 and August 21, 2013 at Citra, and September 3, 2012 and August 26, 2013 at Balm. Nutsedge counts and bell pepper plant heights were collected at 14, 28, and 42 d after planting (DAP). Nutsedge counts were taken in the center of each subplot using a 1 m by 1 m square quadrat. Plant heights were measured from 5 bell pepper plants within the center 0.9 m of each subplot. In both years, bell peppers were harvested in a single harvest. Market weight and fruit counts were collected according to USDA grade and standard guidelines (USDA, AMS 2005). Harvest occurred on October 31, 2012 and November 7, 2013 at Citra, and November 26, 2012 and November 14, 2013 at Balm. Data were analyzed using PROC GLM in SAS version 9.2 (SAS, version 9.2; SAS Institute Inc., P.O. Box 8000,

Table 2. Effect of glyphosate and cultivation during the fallow period on total nutsedge (*Cyperus* spp.) control at 14, 28, and 42 DAP in 2012 and 2013 at Balm and Citra, FL.[a]

	Balm			Citra		
Program	14 DAP[b]	28 DAP	42 DAP	14 DAP	28 DAP	42 DAP
	nutsedge m^{-2}					
NT	20 a[c]	27 a	32 a	38 a	43 a	44 a
C	11 b	17 ab	19 b	37 a	40 ab	44 a
G	11 b	14 bc	17 bc	34 a	37 ab	40 ab
CC	11 b	14 bc	16 bcd	21 ab	24 bc	28 bc
GG	4 b	5 c	6 cd	9 bc	12 cd	14 d
GC	8 b	11 bc	13 bcd	13 bc	15 cd	18 cd
CG	4 b	5 c	7 cd	13 bc	15 cd	17 cd
GCG	3 b	4 c	5 d	3 c	5 d	9 d

[a] Year * fallow period interaction and fallow period * fumigation interaction were not significant ($P > 0.05$); therefore, data have been pooled over both years and fumigants.

[b] Abbreviations: DAP, d after planting; NT, nontreated;C, cultivation; G, glyphosate; CC, cultivation followed by (fb) cultivation; GG, glyphosate fb glyphosate; CG, cultivation fb glyphosate; GC, glyphosate fb cultivation; GCG, glyphosate fb cultivation fb glyphosate.

[c] Means within columns followed by different letters are significantly different using Duncan's multiple range test ($\alpha = 0.05$).

Cary, NC 25712) and means were separated with Duncan's multiple range test ($\alpha = 0.05$).

Results and Discussion

Nutsedge Control. Year by fallow period and fallow period by fumigation interactions were not significant; therefore, data were pooled over both years and fumigants. However, interactions were observed between locations; therefore, locations were analyzed separately. At Balm at 14 and 42 DAP; the greatest nutsedge populations were counted in the NT; all other fallow programs had fewer nutsedge (Table 2). At Citra, the NT fallow program had the greatest nutsedge population and was statistically equivalent to C and G fallow programs at all three counting dates. At both locations, the lowest nutsedge populations were present in the GCG fallow programs. At Balm, the GCG fallow program was similar to CC, GG, GC, and CG fallow programs at all three rating dates. At Citra, the GCG fallow program was statistically equivalent to the GG, GC, and CG program, but not the CC fallow program.

Table 3. Effect of glyphosate and cultivation applied during the 2012 and 2013 fallow period on nutsedge species at Citra, FL.[a]

	Purple nutsedge				Yellow nutsedge			
	14 DAP[b]		28 DAP		14 DAP		28 DAP	
Program	2012	2013	2012	2013	2012	2013	2012	2013
	nutsedge m^{-2}							
NT	ab[c]	48 a	6 ab	a	a	22 a	5 a	21 a
C	5 a	45 ab	7 a	49 ab	2 a	22 a	2 b	22 a
G	2 bc	40 ab	4 abc	42 ab	0 b	26 a	1 bc	27 a
CC	2 bc	31 bc	4 abc	33 bc	1 b	9 b	1 bc	11 b
GG	1 c	11 d	2 bc	15 d	0 b	5 b	0 c	7 b
GC	1 c	14 d	2 bc	18 cd	2 ab	9 b	1 bc	9 b
CG	1 bc	17 cd	3 bc	19 cd	0 b	7 b	0 bc	9 b
GCG	1 bc	4 d	1 c	5 d	0 b	2 b	1 bc	4 b

[a] Year * fallow period interaction was significant ($P < 0.05$); therefore data are presented on an individual basis. Fallow period * fumigation interaction was not significant ($P > 0.05$); therefore, data have been pooled over fumigants.

[b] Abbreviations: DAP, d after planting; NT, nontreated; C, cultivation; G=glyphosate; CC, cultivation followed by (fb) cultivation; GG, glyphosate fb glyphosate; CG, cultivation fb glyphosate; GC, glyphosate fb cultivation; GCG, glyphosate fb cultivation fb glyphosate.

[c] Means within columns followed by different letters are significantly different using Duncan's multiple range test ($\alpha = 0.05$).

Nutsedge species composition differed at the Balm and Citra test sites over the course of the study. No differences between purple or yellow nutsedge species were observed among fallow treatments at 28 DAP in 2012 at Balm. At Citra, the population of purple and yellow nutsedge was greater in 2013 compared to 2012 for all fallow programs (Table 3). In 2012, the highest purple and yellow nutsedge counts were in the NT or C fallow programs. All other treatments were similar to the GCG fallow program, which had the lowest populations. In 2013, the NT, C, and G fallow programs had the highest nutsedge populations. The lowest purple nutsedge populations were observed with GG, GC, CG, and GCG fallow programs. For yellow nutsedge populations, these same fallow programs and CC had the lowest populations.

Fumigant treatments, DMDS + Pic and 1,3-D + Pic, had greater nutsedge control than the nonfumigated check across years at 14, 28, and 42 DAP at Balm (Table 4). At Citra, no difference among

Table 4. Effect of fumigation on nutsedge control and bell pepper plant heights over time at Balm and Citra, FL.[a]

Program	Balm 14 DAP[b]	Balm 28 DAP	Balm 42 DAP	Citra 14 DAP	Citra 28 DAP	Citra 42 DAP
	nutsedge m^{-2}					
Nonfumigated	19 a[c]	23 a	27 a	21	23	25
DMDS + Pic	3 b	6 b	8 b	18	21	24
1,3-D + Pic	5 b	8 b	9 b	24	28	31
	bell pepper height, cm					
Nonfumigated	13 b	18 b	25 b	15 b	28	40
DMDS + Pic	14 a	21 a	26 a	16 ab	30	40
1,3-D + Pic	13 b	21 a	26 a	17 a	30	40

[a] Year * fallow period interaction and fallow period * fumigation interaction were not significant ($P > 0.05$); therefore, data have been pooled over years and fallow programs.

[b] Abbreviations: DAP, d after planting; DMDS + Pic, dimethyl disulfide + chloropicrin at 595 kg ha^{-1}; 1,3-D + Pic, 1,3-dichloropropene + chloropicrin at 337 kg ha^{-1}.

[c] Means within columns followed by different letters are significantly different by Duncan's multiple range test ($\alpha = 0.05$).

fumigants for nutsedge counts at 14, 28, or 42 DAP was observed (Table 4).

Bell Pepper Height. The interaction of year by plant height was not significant; therefore, data were pooled across years. However, differences were observed for location, and locations were analyzed separately. No statistical differences in bell pepper heights were observed among fallow programs (data not shown); however, statistical differences were observed among fumigant treatments. At Balm, plants grown in plots fumigated with DMDS + Pic were taller than plants grown in plots fumigated with 1,3-D + Pic or the nonfumigated check at 14 DAP (Table 4). However, fumigation with DMDS + Pic and 1,3-D + Pic allowed for greater plant heights compared to the nonfumigated check at 28 and 42 DAP. At Citra, subplots fumigated with 1,3-D + Pic had taller plants compared to the nonfumigated at 14 DAP, but statistically equivalent to subplots fumigated with DMDS + Pic. No differences were observed between fumigation treatments at 28 or 42 DAP for plant height.

Marketable Yield. The effects of year and location on yield were significant; thus, results for each are presented separately. In 2012, locations were different for total fruit count and total weight; therefore, locations were analyzed separately. No differences in yield were observed among fallow treatments (data not shown). Significant yield differences were observed among fumigant treatments.

At Balm, fruit count and weight was greater from subplots treated 1,3-D + Pic when compared to DMDS + Pic and the nonfumigated control (Table 5). At Citra, subplots fumigated with either DMDS + Pic or 1,3-D + Pic produced equivalent marketable yields based on the total number of fruit and weight, and were greater than the nonfumigated subplots.

In 2013, locations were different for total fruit count and total weight; therefore, locations were analyzed separately. At Balm, fallow programs had no effect on marketable yields based on total fruit count or weight (Table 6). However, at Citra, GG, GC, CG, and GCG fallow programs showed statistically improved total fruit count and weight compared to the NT and single-input fallow

Table 5. Effect of fumigation on marketable bell pepper fruit count and weight in 2012 at Balm and Citra, FL.[a]

Fumigant	2012 Count[b] Balm	2012 Count Citra	2012 Weight Balm	2012 Weight Citra	2013 Count Balm	2013 Count Citra	2013 Weight Balm	2013 Weight Citra
	fruit ha^{-1}		kg ha^{-1}		fruit ha^{-1}		kg ha^{-1}	
Nonfumigated	12,971 c[c]	14,520 b	1,481 b	2,004 b	9,293 b	13,165	1,133 b	2,178
DMDS + Pic[d]	18,198 b	23,813 a	1,569 b	3,485 a	16,566 a	11,035	2,004 a	2,004
1,3-D + Pic	21,296 a	23,813 a	1,917 a	3,398 a	15,691 a	12,390	1,917 a	2,265

[a] Fallow period * fumigation interaction were not significant ($P > 0.05$); therefore, data have been pooled over fallow programs.

[b] Harvest data included marketable yield and marketable fruit count including U.S. No.1, No. 2, and Fancy grades (USDA).

[c] Means within columns followed by different letters are significantly different using Duncan's multiple range test ($\alpha = 0.05$).

[d] Abbreviations: DMDS + Pic, dimethyl disulfide + cholorpicrin at 595 kg ha^{-1}; 1,3-D + Pic, 1,3-dichloropropene + chloropicrin at 337 kg ha^{-1}.

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Table 6. Effect of fallow weed management including cultivation or glyphosate application during the 2012 and 2013 fallow season on marketable bell pepper fruit count and weight in 2013 at Balm and Citra, FL.[a]

Program	Count[b]		Weight	
	Balm	Citra	Balm	Citra
	fruit ha^{-1}		kg ha^{-1}	
NT[d]	11,035	7,357 d[c]	1,307	958 c
C	11,810	8,906 cd	1,481	1,481 bc
G	14,907	10,648 bcd	1,830	1,655 bc
CC	11,809	14,520 ab	1,394	2,526 a
GG	16,262	15,682 a	2,004	2,962 a
GC	15,101	14,907 a	1,917	2,788 a
CG	14,714	12,003 abc	1,830	2,178 ab
GCG	15,101	14,133 ab	1,830	2,614 a

[a] Fallow period * fumigation interaction were not significant ($P > 0.05$); therefore, data have been pooled over fumigants.

[b] Harvest data included marketable yield and marketable fruit count including U.S. No.1, No. 2, and Fancy grades (USDA).

[c] Means within columns followed by different letters are significantly different using Duncan's multiple range test ($\alpha = 0.05$).

[d] Abbreviations: NT, nontreated; C, cultivation; G, glyphosate; CC, cultivation followed by (fb) cultivation; GG, glyphosate fb glyphosate; CG, cultivation fb glyphosate; GC, glyphosate fb cultivation; GCG, glyphosate fb cultivation fb glyphosate.

programs (C and G). In 2013, fumigation treatments had greater fruit count and weight compared to the nonfumigated check.

The GCG fallow program provided the best control of nutsedge compared to the nontreated and single-input fallow programs. Fallow programs GG, CG, or GC were similar and would be suitable in situations with shorter fallow periods. Similar results were observed in tomato after a single year of fallow weed management (Alves et al. 2013). Alves et al. (2013) completed the fallow period weed management during a single planting season.

The study hypothesis was that a further decrease of nutsedge would occur after 2 yr of fallow weed management programs compared to a single year because of continued nutsedge management. However, this did not occur. The preplant application of halosulfuron to the plastic mulch might have reduced the number of nutsedge in 2012. Halosulfuron provides control of nutsedge until 30 d after application (Vencill et al. 1995). However, the nutsedge counts at 42 DAP (64 d after halosulfuron application) still showed an increase in nutsedge populations over the 2-yr period. Another possible explanation for the increase in nutsedge population over the 2 yr might be the lack of weed control between forming the beds in 2012. No herbicides for nutsedge control where applied during the bell pepper crop growth (approximately 11 wk). Another explanation might be length of the fallow period between crops. After harvest, the mulch was removed and the field was cultivated with no herbicide or cover crop before the initial cultivation for the second year (approximately 14 wk). Zandstra et al. (1974) found that nutsedge populations could increase if a field was left undisturbed for 10 wk.

In summary, soil fumigation with 1,3-D + Pic or DMDS + Pic had a positive effect on bell pepper production. However, the effect of fumigation on nutsedge control, bell pepper height, and marketable yields was not always consistent across locations. Glyphosate in combination with cultivation applied during the fallow period might be a viable option to reduce nutsedge in bell pepper. Fumigation with DMDS + Pic and 1,3-D + Pic might also provide a less-competitive growing environment resulting in taller plant heights and higher total yield compared to a nonfumigated field.

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